INSECTS AFFECTING GREENHOUSE PLANTS.

By Arthur Gibson
And W. A. Ross.

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Insects Affecting Greenhouse Plants

By Arthur Gibson and W. A. Ross

INTRODUCTION

Every grower of plants under glass has, at some time or other, experienced more or less serious losses owing to the presence of destructive insects. Roses, chrysanthemums, carnations, primroses, ferns, snapdragons, cucumbers, lettuce, and many other plants are every year attacked by various leaf-eating and sucking insects, resulting in losses which amount, annually, to many thousands of dollars. Much of this loss may be prevented if growers will adopt the remedies which are recommended in this bulletin.

When a plant is attacked, the grower should observe how the insects feed, as such fact will help materially in deciding upon the proper remedy to apply. Injurious insects may be divided, roughly, into two classes, by the nature of their mouth parts, namely, (1) biting insects which bite and chew their food, such as caterpillars, and (2) sucking insects which suck up their food by means of their beaks, such as the aphids, the true bugs, the scale insects, etc. If the insect is a biting one a stomach poison, such as arsenate of lead, is usually applicable, but if the species is a sucking one, such poisons would be useless because the insect would insert its beak through the poison and reach a safe feeding place beneath. For sucking insects, therefore, contact insecticides are recommended, such for instance as preparations containing tobacco.

Certain insects such as aphids and white fly are best controlled by fumigation with a tobacco preparation or hydrocyanic acid gas.

In Canada, a very considerable amount of money has been spent in improving and developing the greenhouse industry. From an enquiry which we made recently we have estimated that there is commercially about six million square feet of space under glass in Canada. The value of crops grown in 1920 we have placed in round figures to be at least $3,000,000. The industry, therefore, is an important one and as it increases, further important losses from insect pests will undoubtedly take place. In this bulletin we have included information which we believe will assist the grower in recognizing the various kinds of insect pests with which his plants may become infested. The remedies for the insects discussed have been found of value and if the grower will follow these carefully, he will undoubtedly keep the pests under control and thereby protect his plants.

RECOMMENDATIONS FOR CONTROLLING GREENHOUSE INSECTS

General Recommendations

Injury by insects in greenhouses can undoubtedly be kept down to insignificant proportions by prompt and proper treatment. The grower working among his plants every day—watering them, cutting flowers, picking off dead leaves, etc., has every opportunity of observing insect pests before they become destructive. The old adage "a stitch in time saves nine" should be taken to heart by the grower, and in working among his plants he should develop the habit of setting aside or marking any insect-infested plant and treating it before the pest has time to spread through the house. In the case of leaf-eating caterpillars, frequently incipient infestations may be detected from two or more leaves having been fastened together by the caterpillars. The simple remedy of hand picking, therefore, should be practised whenever possible, the infested material being burned or destroyed in some other way.

As in the garden, it is important that weeds of all kinds be kept down. During the summer months particularly, weeds if allowed to become established will surely attract insects from the outside, which may develop and cause serious injury to crops forced later in autumn and winter. Weeds in the neighbourhood outside should also be kept down to a minimum. Crop refuse and rubbish of all kinds should not be allowed to accumulate. The prompt destruction of such useless material will do away with conditions frequently suitable for the harbouring of insect pests.

In selecting soil for the greenhouse it is important to see that it is free from soil-infesting insects, such as cutworms, white grubs and wireworms. Manure may also introduce pests. If there is reason to believe that the soil or manure is infested with destructive insects, the same should be sterilized before planting to crop. (See page 56).

During recent years important greenhouse insects such as the Florida Fern Caterpillar, the Chrysanthemum Midge, the Rose Midge, etc., have been introduced into Canadian greenhouses on plants imported from the United States. The florist, therefore, would be well advised to examine carefully new stock imported at any time. Promptness in dealing with slight infestations of insects which may be present will save much time and considerable sums of money which it may otherwise be necessary to spend later.

In the greenhouse as well as in the garden, it has frequently been found advisable to adopt a system of rotation of crops. The common white fly for instance, is very injurious to tomato, primrose and certain other plants; if new locations are used for such crops, the control of the insect will be easier.

Insecticides and their Application

Insecticides for controlling outbreaks of injurious insects in greenhouses are usually applied in solution. For this purpose a sprayer is desirable. There are many kinds of hand sprayers on the market which are suitable for greenhouse conditions. An important consideration is that the implement should distribute the liquid evenly and as a fine spray.

The following insecticides have been found of value under greenhouse conditions.

Arsenate of Lead—

For leaf-eating caterpillars, such as the Oblique-banded Leaf-roller. It remains much longer on the foliage than Paris green, not being washed off to the same extent by watering. The powdered arsenate of lead is used in the strength of 1½ to 2 pounds to 40 gallons of water, the paste form in the strength of 3 to 4 pounds to 40 gallons of water.

Paris Green—

For thrips and leaf-eating caterpillars.

Liquid application.—Use in the strength of 4 ounces to 40 gallons of water, with about half a pound of fresh lime added. Where only a few plants are being treated one teaspoonful, with the same quantity of lime, to a pail of water is sufficient.

Dry application.—One pound of Paris green mixed with 20 pounds of land plaster, slaked lime or other perfectly dry powder.

Pyrethrum Insect Powder—

For the Florida Fern Caterpillar.

Tobacco Extracts—

For aphids, Chrysanthemum Midge, scale insects, Cyclamen Mite, etc.

Commercial nicotine extracts such as "Black Leaf 40", "Nicotine-sulphate, 40%", "Nicofume" and "Nikoteen" are sold by nearly all seedsmen and are commonly used in greenhouses both as sprays and fumigants. They should be used at the strength recommended by the manufacturers. It is desirable to add soap to all diluted nicotine sprays at the rate of about 2 pounds to 40 gallons of mixture.

Soap Solutions—

For white fly, scale insects and spinning mites.

Poisoned Bait—

For cutworms and such creatures as slugs and millepedes.

Dusts, such as tobacco and lime—

The former for the Rose Midge and millepedes, the latter for slugs.

Kerosene Emulsion—

Recommended particularly in connection with the control measures advised for the Rose Midge. Kerosene emulsion is made as follows:

Kerosene (coal oil)	2 gallons
Rain water	1 gallon
Soap	½ pound

Heat the water, cut the soap into fine shavings and add them to the water stirring till all is dissolved, then pour this into the kerosene and churn the whole violently with a syringe or force pump for about five minutes or until a thick creamy emulsion is produced. This makes the stock solution which, as it cools, thickens into a jelly-like mass. When required for use dilute with nine times its measure of warm water. The stock solution when properly made will keep for months if kept from the air.

Other Insecticides—

In addition to the above, there are other insecticides sold by seedsmen and others which on the whole will be found of value. If they are used by florists, the directions attached should be followed carefully.

Hydrocyanic Acid Gas Fumigation

Such insects as white fly, plant lice and thrips may be controlled by fumigation with hydrocyanic acid gas. Owing to the fact that the degree of tightness in greenhouses varies so much, no general recommendation can be made as to the required amount of cyanide which should be used for each 1,000 cubic feet of space. Some kinds of plants, too, are easily injured by fumigation, and for

this and the former reason, every grower must find out for himself just what dosage is efficient and at the same time safe. For tight greenhouses with "lapped" glass, the initial dose should be as follows:

Sodium cyanide (128%)..... $\frac{1}{8}$ ounce
Commercial sulphuric acid..... $\frac{3}{16}$ fluid ounce
Water..... $\frac{1}{4}$ ounce
for each 1,000 cubic feet of space.

In houses where the glass is "butted" the initial dose should be:

Sodium cyanide (128%)..... $\frac{1}{4}$ ounce
Commercial sulphuric acid..... $\frac{3}{8}$ fluid once
Water..... $\frac{1}{2}$ ounce
for each 1,000 cubic feet of space.

From the above initial dose the strength may be increased until the results desired are secured. Houses containing a number of different kinds of plants

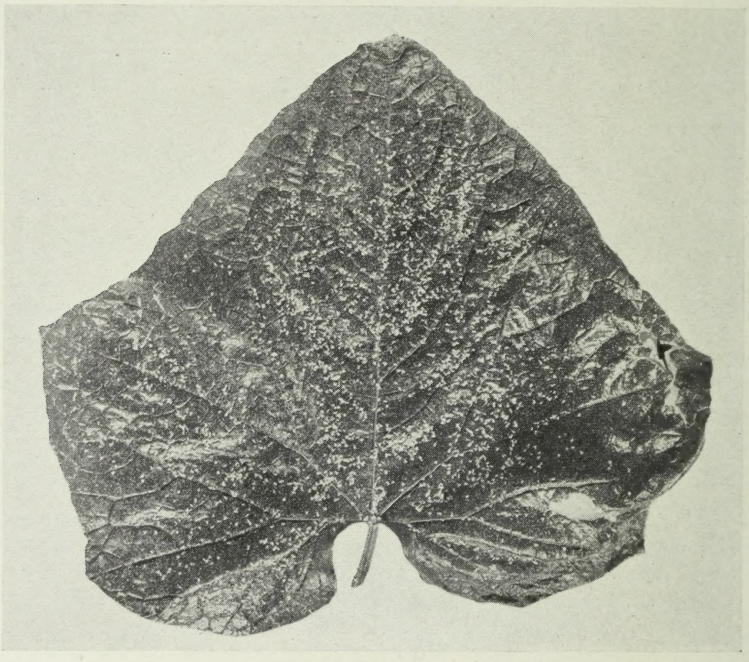

Fig. 1—White Fly adults on cucumber leaf killed by fumigation. (Original).

may even stand a strength of three-quarters of an ounce of sodium cyanide for each 1,000 cubic feet of air space. In estimating the required dose it should be noted that for every ounce, or portion thereof, of sodium cyanide, one and one-half times this amount of sulphuric acid is required, and twice the amount of water.

Fumigation should take place at night when there is no wind and when the temperature of the house is not less than 52 degrees F. and not more than 70 degrees F. It is advisable not to water the plants during the twelve hours preceding the fumigation. Before fumigation, all openings should be closed up tightly except the entrance door. The gas should be generated in earthenware crocks, the size of which will depend upon the house to be fumigated. A house say 80 feet in length would require three earthenware vessels such as ordinary butter crocks. When the amount of cyanide required for the whole

house is weighed, it should be separated into equal packages, the number depending upon the number of crocks required, and the same care should be exercised in measuring the sulphuric acid.[1] The cyanide may be placed in thin paper bags. The crocks should be evenly distributed on the floor throughout the length of the house. The necessary amount of water should be placed in the crocks and the measured quantities of sulphuric acid added. *Always add the acid slowly to the water, never the water to the acid.* When this has been done and the ventilators or other openings having been closed tightly the operator beginning at the farthest crock from the entrance door, should quickly drop a bag of cyanide into it, proceed to the next and so on, after which the door should be closed tightly and locked securely from the outside. Over night fumigation should begin about eight or nine o'clock in the evening and continue until early the following morning, when the house should be opened up and thoroughly aired before anyone is allowed to enter.

It should always be borne in mind:—

1. That hydrocyanic acid gas is one of the most deadly poisons known, and the greatest care should always be exercised in its use to see that none of it is breathed into the lungs. Two persons should always be present during such fumigation in case of an accident.
2. That the cubic contents of the house to be fumigated should be accurately determined, otherwise, failure may result.
3. That the earthenware crocks used should be deep enough to prevent bubbling over when the cyanide is added to the acid and water.
4. That the house should be thoroughly aired after a fumigation for about half an hour, before anyone is allowed to enter. The odour of the gas resembles somewhat that of peaches and the house should not be entered while such odour is present. In winter, if there is a slight wind a ventilation of ten to fifteen minutes, using side and top ventilators, will be sufficient and should not lower the temperature of the house to a dangerous point, unless the temperature outside is close to the zero mark. In many commercial houses ventilators cannot be opened from the outside. When such is the case the doors at either end of the house should be opened.
5. That all residue remaining in the crocks after fumigation should be buried in a deep hole away from all domestic animals.
6. That any cyanide or sulphuric acid left over after a fumigation should be kept in tight bottles and labelled POISON and not left around carelessly.
7. That hydrocyanic acid gas will not destroy the eggs of the white fly, so a second fumigation may be necessary. Many florists fumigate at regular intervals to control white fly and plant lice.

Experiments conducted by the United States Bureau of Entomology have demonstrated that dosages of half of an ounce to three-quarters of an ounce of cyanide for each 1,000 cubic feet of space may be used with safety on a great range of plants, provided the exposure does not exceed an hour. This shorter exposure at these strengths has been found to be effective not only against plant lice, white flies and thrips, but also against orthezia and some of the common scale insects. Genistas and certain other plants have been burned to a slight extent, but these soon outgrew the injury. Such fumigation, of course, should be conducted after sundown.

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[1]An 8-ounce graduate should be procured for the purpose of measuring the water and acid

In order to air the houses quickly after fumigation, an arrangement may be made to open the ventilators from the outside by fitting a pipe on the bevel gear shaft after removing the wheel; by running this pipe outdoors through a hole in the wall and then fitting the wheel on to the end of the pipe. During periods of zero or other specially cold or windy nights it is considered inadvisable to fumigate. During such weather the health of the plants would doubtless be affected by the ventilation suggested. Under milder winter conditions, if care be exercised and only "leeward" ventilators opened to a distance of from three to six inches, an airing of fifteen minutes would doubtless be sufficient, and would not lower the temperature to a sufficient extent to affect the plants.

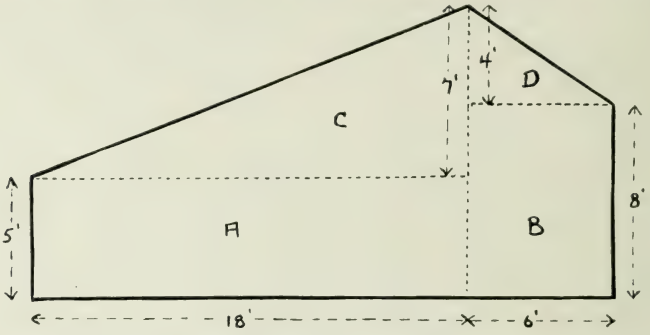


Fig. 2—End view of three-quarter span house to illustrate method of computing cubic contents.

Method of Computing the Cubic Contents of a Greenhouse

The simplest method of computing the cubic capacity of an even-span greenhouse is to add height to gutter and height to ridge and divide by 2; multiply this by the width of the greenhouse; then multiply the result by the length of the greenhouse. For example, supposing a house has the following dimensions—height to gutter 6 feet, height to ridge 12 feet, width of greenhouse 30 feet, length of greenhouse 100 feet—the cubic capacity is computed in the following way:—

$$\left\{\frac{(\text{Height to gutter} + \text{height to ridge})}{2} \times \text{width}\right\} \times \text{length}$$

$= 6 + 12 \div 2 = 9$ feet; $9 \times 30 = 270$ sq. feet; $270 \times 100 = 27{,}000$ cubic feet.

In ascertaining the cubic contents of a three-quarter span house, the first step is to make a rough diagram of the end view (fig. 2) and divide it into two rectangles and two triangles as shown in the figure. Then compute the area of each rectangle by multiplying the base by the height, and the area of each triangle by multiplying half the base by the perpendicular. Add the areas together and multiply the total by the length of the greenhouse. For example, in a house 100 feet long and with other dimensions as shown in fig. 2: A, $18 \times 5 = 90$ square feet; B, $6 \times 8 = 48$ square feet; C, $7 \times 9 = 63$ square feet; D, $4 \times 3 = 12$ square feet. $A + B + C + D = 213$ square feet. $213 \times 100 = 21{,}300$ cubic feet—the cubic capacity of the house.

Tobacco Fumigation

Such insects as plant lice, or as they are generally spoken of as "aphis", may be controlled by fumigation with tobacco. There are various nicotine preparations on the market and the grower in using these should follow carefully the directions attached. There are certain plants, however, as for instance the violet, which are injured by tobacco fumigation. Tobacco leaves or stems

have been used to a considerable extent, but the easily obtained commercial preparations sold by seedsmen have come into wide use and give general satisfaction. No general recommendation can be given regarding the number of times houses should be fumigated with tobacco. This is a matter which the grower will have to decide himself and will, of course, be governed by the degree of infestation. In some houses it may only be necessary to fumigate two or three times during the winter, while others may require that number of fumigations within a week.

LEAF-EATING INSECTS

The Greenhouse Leaf-tyer, *Phlyctænia ferrugalis* Hbn.

The Greenhouse Leaf-tyer, a European insect, has during recent years increased to a serious extent in many greenhouses in eastern Canada. The

Fig. 3—Bed of marigold plants destroyed by the Greenhouse Leaf-tyer. (After Gibson).

first Canadian record we have of injury by the caterpillars refers to an outbreak which occurred in a large greenhouse in Toronto, Ont. The actual year of introduction is not known, but it is thought that this was in 1896 or 1897. Since, the leaf-tyer has been found at other points in the province of Ontario, and we also have reports of injury from various points in the provinces of Quebec, New Brunswick, and Nova Scotia. In addition to these provinces, an important infestation was also investigated at Winnipeg, Man., in 1917. The species is doubtfully reported from the province of British Columbia, but we have no records of injury therefrom. The insect was doubtless introduced into Canada from the United States where it has long been known as a pest of greenhouse plants.

DESCRIPTION AND HABITS

The Egg.—The egg is about one-half millimeter in width, round in outline, much flattened, slightly raised in centre, pearly-white, coarsely reticulated, and from its flattened appearance remarkably like that of the Codling Moth. Before hatching the black heads of the young larvæ are very apparent through the shell. The eggs are laid on the underside of the leaves either singly or several together forming a mass; in the latter case they overlap. Eggs kept under observation at Ottawa hatched in fourteen days.

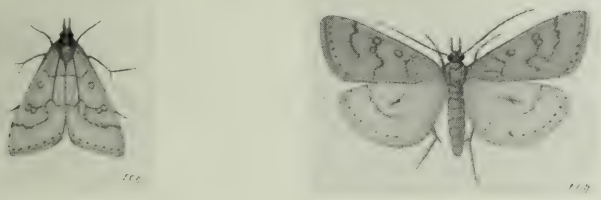
Fig. 4—Leaf of marigold showing injury by the Greenhouse Leaf-tyer; caterpillars at work on leaf. Ageratum plant at right destroyed by caterpillars. (After Gibson).

The Larva or Caterpillar.—The larva, when it emerges from the egg, is in general appearance of a semi-translucent creamy-white colour, the body bearing long, whitish hairs. After feeding it is of a light greenish appearance. The young larvæ feed on the underside of the leaves and eat little holes into the soft tissue. When at rest they curl the head and front segments around to the side

of the body and if disturbed, fall and hang suspended on silken threads. The larvæ have five stages, or instars. They do not change very markedly when developing. At full growth they are about three-quarters of an inch in length. The dorsum or back is dark green, the sides and under surface paler. Longitudinal stripes are also present on the back.

We have found larvæ in all stages of development working at the same time and at various seasons. The generations undoubtedly overlap. The caterpillars feed almost entirely on the underside of the leaves, eating away the soft green tissue and spoiling the appearance of the foliage. In the case of the mature larvæ conspicuous portions of the leaves are entirely eaten. The caterpillars are generally found within a slight silken web. In many instances two leaves are brought together and fastened by threads of silk, the larva feeding on the soft tissue on the underside of the upper leaf. Figure 3 shows the destruction of plants which frequently results from the work of the caterpillars. The bed of ageratum plants in a large greenhouse in eastern Ontario from which the plant in the illustration (figure 4) was obtained was completely destroyed by the larvæ. The separate leaf shows characteristic injury to the foliage of marigold. On the leaf several caterpillars at work may be observed.

When ready to pupate, the caterpillar simply folds over a portion of a leaf and fastens it with threads of fine white silk, or choosing a central portion of a leaf, draws down another leaf to serve as a covering and then changes to a pupa. The cocoon itself is very slight and is merely a web or covering of slender threads of white silk. The pupa in length is about three eighths of an inch and in colour is shining brown, becoming darker with age. The length of the pupal stage is from seventeen to twenty days.



A B

Fig. 5—Moth of Greenhouse Leaf-tyer with wings spread, and same at rest; about twice natural size. (Original).

The Moth.—This is of a rusty-brown colour, the wings being crossed with darker lines. The hind wings are paler than the front wings. When at rest the moth measures three-eighths of an inch at widest part and with the wings spread a little over five-eighths of an inch. During the daytime the moths have the habit of resting on the underside of leaves or in corners or other sheltered places in the greenhouse. At night they are active, flying about among the plants.

From observations made at Ottawa during the winter months, from seventy to seventy-five days, approximately, elapsed from the time the eggs were laid until the resultant moths appeared. Under greenhouse conditions, therefore, there is time from the end of September until the end of May for at least three or possibly four generations.

Food Plants.—In Canada, the larvæ have been particularly destructive to cineraria, primula, snapdragon, ageratum, rose, chrysanthemum, marigold, geranium, aster, and to a lesser extent to heliotrope, mignonette, sweet pea, fern, salvia, canna, azalea, cyclamen, wall-flower, violet, German ivy, tomato, cabbage and lettuce. This list of food plants is by no means complete. The caterpillars attack a wide range of greenhouse plants, as in the United States in addition to the plants mentioned above they have infested nodding thistle

(Carduus), wandering jew, ground ivy, Kenilworth ivy, dahlia. justicia, anemone, matricaria, passiflora, plumbago, ruellia, tydæa, lobelia, veronica, lantana, deutzia, clover, strawberry, parsley, and cucumber. It will, therefore, be seen that almost any soft-leaved greenhouse plant is liable to be attacked.

Under outside conditions, in the United States, this insect has caused injury to celery, for which reason it was designated popularly as the Celery Leaf-tyer, as well also to the leaves of tobacco, cabbage, sugar beet, spinach, nasturtium, begonia, carnation, and a few wild plants.

CONTROL

During the winter of 1918-1919, the Greenhouse Leaf-tyer was freely complained of as a serious pest in many greenhouses in eastern Canada. Conditions were specially investigated and control measures instituted. Spray mixtures of various kinds were devised and tested in large greenhouses in Ottawa, Montreal and Halifax. The following mixture gave excellent results:

Soluble sulphur.....1 ounce by weight
Nicotine sulphate (40%).....1 fluid ounce
Water.....6 gallons

In some houses which were seriously infested three applications of the mixture, at intervals of one week, controlled the pest. During the past year we have received a number of letters from commercial florists reporting success from the use of this spray.

Other Control Measures.—The old remedies of hand picking, fumigating, etc., have proved to be only partially useful in keeping down the numbers of this pest. When the infestation is slight, the collection of the caterpillars by hand, should of course be practised, and in addition as many as possible of the moths seen either at rest or flying should be destroyed. The moth is shown at fig. 5.

The Florida Fern Caterpillar, *Callopistria floridensis* Gn.

The first occurrence of the Florida Fern Caterpillar in Canada was noted in September, 1915, in greenhouses at Weston, Ont. The caterpillars were found on some ferns imported from Chicago, and the insect had doubtless been introduced with such shipment. During the winter of 1915-16 we had an opportunity of studying the life-history of the insect and observing its habits. Since, the caterpillars have been found in destructive numbers in greenhouses in the Montreal district.

DESCRIPTION AND HABITS

The Egg.—We have been unable to secure eggs of the moth, either by searching in greenhouses or from living moths kept under observation in captivity. Davis[1] describes the egg (laid in confinement) as "circular in section, about one-fiftieth of an inch in diameter, slightly flattened, ribbed longitudinally and transversely," and states that in colour it "is pale greenish with a faint yellowish tint, much resembling the colour of the new fern fronds." The same author states that in confinement the moths deposited their eggs singly on the under surface of the new leaves. Weiss[2] records an incubation period of from five to seven days.

The Larva or Caterpillar.—During January, February and March, 1916, several lots of larvæ representing various stages were received at Ottawa. At first the larva is pale green without markings. In the second stage, rather indistinct, pale whitish, longitudinal stripes appear on the body, which are more conspicuous in later stages. When mature the caterpillar is from about

[1] 27th Report State Entomologist of Illinois.
[2] Can. Ent. XLVII, 23.

PLATE I.

THE FLORIDA FERN CATERPILLAR, *Callopistria floridensis* Gn.

Fig. 1—Two forms of larvæ; 2, cocoon; 3, moth at rest; 4, female moth; 5, male moth; 6, Boston fern plant, showing injury by larvæ; 7, tip of frond of Boston fern destroyed by larvæ. (After Gibson).

one and a quarter to one and a half inches in length. It is a beautiful larva and varies strikingly in colour, some specimens being brownish with a greenish tinge, others green and others again dull reddish, or dark reddish-brown. The longitudinal stripes on the body are still present, being more pronounced in some specimens than in others. Some of the larvæ have a conspicuous band, yellowish-white in colour, along either side, as indicated in plate I, fig. 1. In addition to the longitudinal stripes on the body, all specimens have a conspicuous dark coloured band extending across the front of the thoracic shield, immediately behind the head, and this character should serve to determine the species.

The caterpillars are active feeders and when several occur on a single plant, they soon effect serious damage. Like other noctuid larvæ they prefer the young and tender leaves, but will readily attack the older and larger leaves, and even eat into the more tender portions of the stems. In an experimental breeding cage, one frond measuring 16 inches in length was entirely denuded, by one last stage caterpillar in four days. In the Weston outbreak which we investigated, the plants were indeed an unsaleable lot, the fronds of most of them being eaten to a greater or less extent and in many cases the plants had been almost entirely defoliated. Many had been destroyed to the extent shown in plate I, fig. 6. At the height of the infestation from three to a dozen larvæ were shaken from a plant growing in a five-inch pot. When not feeding the caterpillars have the habit of resting on the stems chiefly towards the base of the plants.

When the caterpillar completes its growth, it leaves the plant and makes an earthen cocoon on the surface of the soil. The earth is held together by many strands of silk spun by the larva, which gives the structure considerable strength. The cocoon shown in plate I, fig. 2, is about natural size. The pupa inside the cocoon is reddish-brown in colour and in general appearance similar to that of the common garden cutworms. In about two weeks the moth emerges.

The Moth.—The moth is a rather striking species and quite different from any other form found in Canada. The wings in general are brown, with a darker velvety rather V-shaped costal area near the centre of the wings. Towards the apex of the wings and at the base of each wing the colour is also dark brown. Some examples are, in general, of a darker brown shade than others. The markings on the wings are shown in figs. 4 and 5, plate I. The bands across the forewings are whitish tinged with pink. The hind wings are of a uniform paler brown colour, lighter towards the base. The body corresponds in general to the colour of the wings. In the male there is a conspicuous widening of the antennæ near the head. The legs are conspicuously tufted. With the wings expanded the moth measures about one and one-quarter inches in width. Being nocturnal in habit they are seldom seen during the day.

Food Plants.—In the Weston, Ont., greenhouses, the ferns attacked were Boston, Whitmani and Scotti, and in the Montreal greenhouses the same varieties were attacked. Other varieties of ferns have also been recorded as being subject to injury.

CONTROL

Hand Picking.—Large numbers of the larvæ were destroyed by hand picking in the Weston houses. On occasions, the pots were shaken individually and caterpillars crushed with the foot as they dropped. In one of the Montreal houses the shaking of the caterpillars from the plants was done three times a week for about three months, but even this laborious method of control was not satisfactory.

Arsenical Mixtures.—Spraying with mixtures containing arsenate of lead did not prove successful. When used in sufficient strength to destroy the caterpillars, a white deposit remained on the foliage which was difficult to remove even with forceful watering. Mixtures containing Paris green, too, did not give satisfactory results.

Pyrethrum Insect Powder.—In one of the large Montreal houses, dusting with pyrethrum insect powder twice a week was found to give the best results. Two weeks after this remedy had been applied not a single caterpillar could be found. The following spray also proved effective:—

Fresh pyrethrum insect powder	$\frac{1}{2}$ pound
Common laundry soap	$\frac{1}{4}$ pound
Water	8 gallons

The soap should be dissolved in a small quantity of warm water after which the insect powder and water should be added to make up eight gallons of mixture. Applications should be made once a week for four or five weeks.

The Oblique-banded Leaf-roller, *Cacoecia rosaceana* Harris.

This leaf-roller has frequently been recorded as causing injury in the greenhouse. The species has a wide distribution and out-of-doors is known to attack a variety of plants. It has not as yet, however, in Canada, developed into a greenhouse pest of importance. Owing to its injuries in orchards in Nova Scotia, it has been discussed as an apple pest by Sanders and Dustan[1].

DESCRIPTION AND HABITS

The Egg.—The egg is small, flat, of a pale greenish colour and a number are laid together, all forming a compact mass of an oval shape. Five egg masses collected outside in Nova Scotia had an average of 159 eggs per mass. The egg stage lasts about one week.

The Larva or Caterpillar.—The young caterpillar is of a pale yellow colour becoming darker yellow, yellowish-green and green as it develops. When mature it is about three-quarters of an inch in length, the colour of the back being dark green, the under portion lighter green. The head is black or dark brown. When fully fed it pupates within a folded leaf and in about three weeks the moth emerges.

In addition to feeding upon the leaves, this caterpillar has the habit, also, of feeding on the buds and even the flower petals. Owing to its habit of rolling over a leaf, fastening this with threads of silk, and living mostly within such shelter, it is known popularly by the name of leaf-roller. When disturbed the caterpillar has the habit of wriggling backwards and dropping from the plant or hanging suspended on a silken thread.

The Moth.—The moth has a wing expanse of about one inch. The front wings are of a light brownish colour crossed with darker brown lines and three broad, oblique, dark brown bands. The hind wings are of a yellowish-orange colour, the basal area darker. The moths may be seen flying among the plants or resting on the framework of the house.

Food Plants.—This leaf-roller in greenhouses is known particularly as a pest of roses and carnations. Owing to the wide range of food plants upon which it feeds out-of-doors, other plants may, however, at times be attacked.

CONTROL

We have not had an opportunity of testing the value of any control measures for this insect, owing to the fact that no serious infestations have come to our notice.

Poisoned Sprays.—In the United States, mixtures containing arsenate of lead have controlled outbreaks of the caterpillar. The mixture which we have used successfully for controlling the Greenhouse Leaf-tyer, mentioned on page 14, is worthy of a trial.

[1]Bull. No. 16, Ent. Branch, Dom. Dept. of Agriculture.

Hand Picking.—As is the case with other leaf-eating caterpillars, infested leaves—those which are seen to have been rolled over—should whenever noticed, be gathered and burned.

The Rose Leaf-tyer, *Cacoecia parallela* Rob.

This insect on occasions has caused injury in greenhouses in the province of Ontario. In 1899 and 1900, the caterpillars effected important damage at Hamilton, Ont., and an account of these infestations is given in the report of the Dominion Entomologist for the year 1900.

DESCRIPTION AND HABITS

The Larva or Caterpillar.—When full grown the caterpillar is about one inch long. In colour it is dull green, darker on the back. On the body are conspicuous white warts or tubercles, each of which bears a rather long hair.

Injury by the caterpillars was first noticed in June, 1899, and in 1900, the larvæ were present in conspicuous numbers from March until about the middle of October. The caterpillar feeds on the green foliage and like the Greenhouse Leaf-tyer, has the habit of drawing the leaflets together by means of silken threads and feeding inside such shelter. When it becomes full grown it spins a light cocoon among the leaves, two or three of which it gathers together. The pupal period of specimens bred at Ottawa, in 1900, was about nine or ten days.

The Moth.—The moth, which in a superficial way, closely resembles the well known Oblique-banded Leaf-roller, measures from three-quarters of an an inch to very nearly an inch in expanse of wings, and in greenhouses there are several broods in a season. The colour of the upper wings is a pale brown, crossed obliquely by three bands of a much darker shade, the central one of which is clearly defined at its margins. The other two bands fill up the apical and basal areas of the wings. In many specimens the basal band is almost obliterated. The whole wing surface is loosely reticulated with indistinct basal lines. Under wings paler than the upper.[1]

Food Plants.—The only plant attacked in greenhouses, of which we have record, is the rose.

CONTROL

The remarks on the control of the Oblique-banded Leaf-roller (page 17) would be equally applicable for this insect.

The Variegated Cutworm, *Lycophotia margaritosa* Haw.

This common and widely distributed cutworm is occasionally found in destructive numbers in greenhouses. The species is cosmopolitan in distribution and in Canada occurs almost everywhere. Out-of-doors, probably no other kind of cutworm has done as much damage in a single season as has this species. In one season alone, in Canada and the United States, crops having a market value of over two million dollars, have been destroyed.

DESCRIPTION AND HABITS

The Egg.—The eggs of cutworm moths are, in general, similar in appearance, being pale in colour, dome-shaped and less than one millimeter in diameter. If examined under a lens they are seen to be beautifully ribbed, the ribs being joined by indistinct cross-ridges. A single female moth lays several hundreds of eggs. These are clustered on the leaves of weeds, grasses, shrubs, etc.

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[1]Report of Ent. and Bot., Dom. Exp. Farms, 1900.

The Larva or Caterpillar.—The Variegated Cutworm when mature is a large plump caterpillar measuring about two inches in length by one-fourth of an inch in width. It is variable in colour ranging from pale gray to almost a dull brown, some specimens with a greenish tinge. The body is mottled and streaked with dark brown or black and marked along the side with a conspicuous yellowish band. Between this band and the middle of the back is an interrupted stripe of velvety black blotches bordered more or less with orange. Below this and above the yellowish band just mentioned are a series of blackish curved dashes on either side, one on each segment. Down the centre of the back is a rather thin yellowish stripe which is expanded into a spot in the middle of some of the central segments. These spots are nearly always present on segments four to seven and in some examples the stripe is widened into spots on one or two other segments.

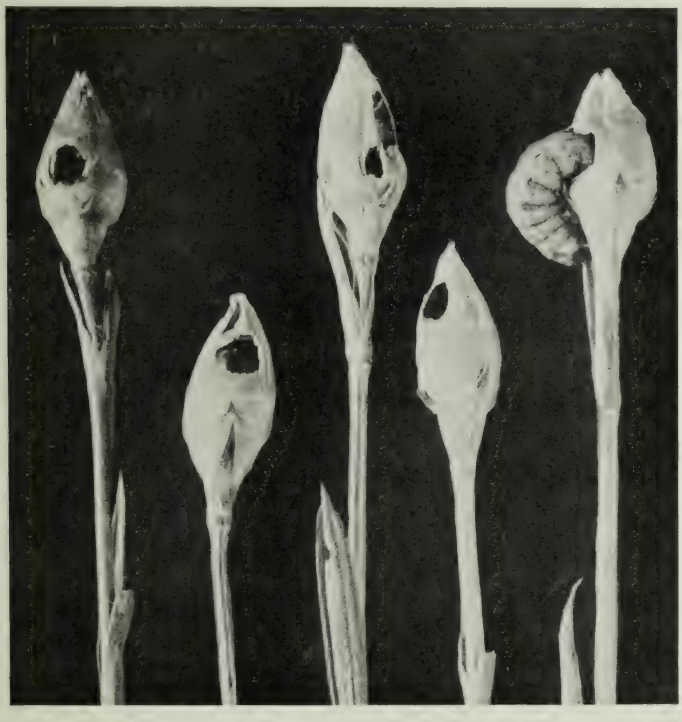

Fig. 6—Carnation buds eaten by the Variegated Cutworm. (After Gibson).

This cutworm has been found attacking carnations, chrysanthemums, violets, etc., in greenhouses. The buds of carnations are eaten into as shown in fig. 6. Infrequently serious injury to chrysanthemums is reported, the cutworms attacking the heads and cutting off the florets. In the field and garden it attacks freely all crops and even does much damage by climbing fruit trees, currant bushes, etc., and eating the leaves. These caterpillars are nocturnal in habit, hiding during the day just beneath the surface of the soil.

The Pupa.—When the caterpillar becomes full grown, it enters the earth and makes an earthen cell in which it changes to a brownish, or dull reddish pupa. In size the pupa is about five-eighths of an inch long and about five-sixteenths of an inch in width at widest part; at the end are two short spines. The moth usually emerges from the pupa in about two weeks' time.

The Moth.—The moth of the Variegated Cutworm is also extremely variable. It expands from about an inch and a half to nearly two inches in width. The front wings are of some shade of brown, or reddish-brown, usually darker along the outer margin. Some specimens are more or less blotched with pale brownish yellow, while in others the whole lower and central area of the wings is pale brownish-yellow. The centre of the hind wings is pearly-white, with a purplish reflection, the edges being bordered with brown.

The cutworm moths are also nocturnal in habit, being seldom seen during the day time. In the early evening they appear in search of the nectar of flowers.

CONTROL

Poisoned Bran Mixture.—The following mixture is the one which is now used most extensively for the destruction of cutworms generally. It has been used with success against the Variegated Cutworm.

Bran	20 pounds.
Molasses	1 quart.
Paris green or white arsenic	½ pound.
Water	2 to 3 gallons.

Mix the bran and Paris green thoroughly in a wash tub, while dry. Dissolve the molasses in the water and wet the bran and poison with the same, stirring well so as to dampen the bran thoroughly.

A simple formula for small areas is one quart of bran, one teaspoonful of Paris green and one tablespoonful of molasses, with sufficient water to moisten the bran.

The mixture should be scattered thinly along the rows of plants as soon as cutworm injury is noted. This should be done after sundown so that the bait will be in the very best condition to attract the cutworms when they come out to feed at night.

Hand Picking.—Within small areas, as soon as cutworm injury is noticed the culprits can as a rule be easily located in the soil, about an inch or so beneath the surface, and within a radius of a few inches of the plant, and destroyed by hand.

The Cabbage Looper, *Autographa brassicae* Riley

Injuries by this insect are fortunately of uncommon occurrence in Canada. In the eastern provinces the pest is occasionally destructive to such vegetable crops as cabbages, cauliflowers, lettuce, peas, etc. In greenhouses, we have records of the caterpillar occurring in sufficient numbers to cause important injury to cinerarias, geranium, carnations, tomatoes and lettuce.

DESCRIPTION AND HABITS

The Larva or Caterpillar.—The full grown caterpillar is about an inch and a quarter in length, pale green in colour, with longitudinal whitish stripes. It walks like the measuring worms or loopers, owing to the fact that it has only three pairs of prolegs at the end of the body. When mature it spins a gauzy silken cocoon on the leaves.

The Pupa.—The pupa is plainly visible through the thin silken cocoon. It is reddish-brown in colour and about three-quarters of an inch in length. Specimens which changed to pupæ on January 27, produced the moths on February 23.

The Moth.—The moth is dark in colour, the upper wings being almost black or very dark gray, marked with small white points and indistinct bands, and having a silvery U-shaped spot on the middle of each front wing and a smaller round silvery dot close to it on the outside.

CONTROL

In the outbreaks of the Cabbage Looper in Canada, which have come to our notice, hand picking of the caterpillars proved to be a satisfactory remedy. In the event of this insect becoming more destructive in Canada, doubtless, serious

Fig. 7—Cabbage Looper feeding on cucumber leaf. (Original).

losses in greenhouses would take place. In the report of the Dominion Entomologist for 1900, the following statement is made: "The most practical means of preventing the work of the caterpillars on lettuce in forcing houses is stated to be the keeping of the ventilators closed with mosquito netting. It is thought that the eggs are sometimes laid on plants before they are taken into the houses, but probably the moths gain access to forcing houses more generally through the ventilators."

During December, 1921, an important infestation was discovered in a large greenhouse in the Ottawa district, where serious injury was being effected to the foliage of geraniums. A Paris green spray was applied with excellent results.

The Yellow Woolly-bear, *Diacrisia virginica* Fab.

Occasionally this well known woolly-bear caterpillar is found in destructive numbers in greenhouses in autumn. It is, however, a garden species feeding on a great variety of low growing plants such as dahlia, sunflower, corn, cabbage, clover, etc.

DESCRIPTION AND HABITS

The Larva or Caterpillar.—This is the only form of the insect which we have found in greenhouses. When mature the caterpillar is about one and a half inches in length, and as the name "woolly-bear" would indicate it is clothed with

dense clusters of stiff hairs, not always of a yellowish colour, however, as in many specimens these are of a dark rusty or reddish-brown colour, or even nearly white. The body colour also varies, and in the paler specimens a more or less broken lateral blackish stripe, as well as bands of the same colour across the back between each of the segments may be seen.

When full grown, in autumn, the caterpillar spins a cocoon and passes the winter as a pupa inside this coarse silken cover. In May and June of the following year the moths appear.

The injuries to plants in greenhouses upon which we have found these caterpillars feeding in Canada, relate particularly to chrysanthemums and marigolds. The caterpillars had undoubtedly migrated to the greenhouses from nearby gardens. When such happens injury is likely to take place to almost any succulent plant reached by the larvæ. As mentioned above, they are very general feeders and in addition to low growing plants, they are also found on the foliage of bushes and even trees. They are active feeders and if present in numbers cause very noticeable injuries by eating the leaves.

CONTROL

Hand Picking.—The simple remedy of hand picking will undoubtedly answer in most cases. The larvæ are conspicuous and should be soon noticed when the grower is working among his plants.

Fig. 8—Greenhouse tomatoes destroyed by the Corn Ear Worm; caterpillar feeding on tomato at left. (Original).

The Corn Ear Worm, *Heliothis obsoleta* Fab.

This well known pest of sweet corn was found causing important injury to the fruit of the tomato in greenhouses in Ontario in October, 1921. In this year there was an exceptional outbreak of this insect in Canada. The only other record we have of the caterpillar being found in a greenhouse, refers to a single specimen found at Ottawa on October 28, 1898, feeding on *Pelargonium.* The injury in gardens is largely confined to the ears of sweet corn, but tomatoes also are occasionally attacked.

DESCRIPTION AND HABITS

The Larva or Caterpillar.—The caterpillar, when mature, "is from one and one-quarter to one and one-half inches in length. It varies in colour from a light green to dark brown, with rather indistinct stripes on the back and a wider, conspicuous, pale-coloured band along the side. The head is of a yellowish-brown colour".[1]

[1]Cir. No. 14, Ent. Br., Dom. Dept. Agriculture.

The injury to the fruit of tomato referred to above is shown at fig. 8. It will be seen that the inside of the fruit is freely devoured by the caterpillars.

CONTROL

Hand Picking.—Should this caterpillar be found in greenhouses, the probability is that hand picking will be a satisfactory remedy. Larvæ thus collected may be destroyed by dropping them in a pail or other vessel containing water on the top of which is a film of coal oil.

The Chrysanthemum Leaf-Miner, *Phytomyza chrysanthemi* Kowarz.

This insect, which is also known as the Marguerite Fly, has a wide distribution and has been a pest of considerable importance in Canada in the provinces of Quebec, Ontario and British Columbia. During recent years the chief reports of injury have been received from florists in the district of Montreal.

Fig. 9—Chrysanthemum leaf showing work of Chrysanthemum Leaf-miner. (Original).

DESCRIPTION AND HABITS

The Egg.—The egg is very small and according to Smulyan[1] varies in in size from .25 to .33 mm. in length by .14 to .17 mm. in width. It is smooth, of an elongate-oval shape and in general, colourless. In March, 1911, infested foliage was received at Ottawa from Vancouver, B.C., and a female fly was observed to oviposit.

An unpublished note made by the late Dr. C. Gordon Hewitt reads as follows: "Single egg is deposited near midrib. A hole is bored by means of the ovipositor, which is pushed in, the distal portion of the abdomen being at right angles to the surface of the leaf. The ovipositor worked by a screwing motion of the abdomen then scoops out a circular space in the sub-epidermal tissue of the leaf in which the egg is deposited. The fly then moves back and applies the proboscis, for what purpose I could not see, rapidly several times to the puncture.

[1]Bull. 157, Mass. Agr. Exp. Station.

The whole process takes less than one minute". The latter action was doubtless for the purpose of feeding. A single female may lay from 125 to 150 eggs. The length of the egg stage under normal greenhouse conditions is about five days.

The Larva or Maggot.—The young maggot on hatching from the egg, at once begins to feed upon the tissues immediately below the epidermis of the upper surface. The larva, which is colourless, as it develops makes conspicuous mines, irregular in shape and size, in the leaves as indicated in fig. 9. This injury has a decided weakening effect upon the plants, affecting their whole growth, which is frequently seen in the small size of the flowers produced. Badly infested leaves after drying up remain attached to the plants and where the infestation is serious the smaller plants particularly may be killed outright. When full grown in about two weeks or so, the maggot is 3.5 mm. in length; it changes to the puparium stage within the mine and after a further period of about two weeks the adult fly emerges.

The Fly.—The adult fly is a small, two-winged insect, about one-twelfth of an inch in length, the front portion of the body being grayish in colour, the posterior portion blackish. In habit, as has been stated by Smulyan, the flies "crawl lazily about, or make their way from leaf to leaf and from plant to plant in a skipping or hopping flight, very seldom flying more than a few feet at a time." The same author states that "the females, at least, feed during their adult life, the food being the juices of the leaves of the host plants. To this end the epidermis of the leaf is pierced and the parenchyma in contact with it at that point is cut or macerated by means of the tubular ovipositor." In 1914, we had an opportunity of examining a large number of punctures made by the females and it was observed that all those on the upper surface and a majority of those on the lower had been made for feeding purposes. Thirty-three punctures on the upper surface were examined and in only one of these was an egg found; on the lower surface eight eggs were found in eighteen punctures examined. This feeding injury results in the formation in the leaves of wart-like growths.

Food Plants.—Marguerite is the favourite food plant of the insect in Canada. One grower in the Montreal district found the insect, in addition to marguerite, working in the foliage of bridal rose, chrysanthemum, gazania and German ivy. The larva is also known to attack feverfew, helianthus, goldenrod, ragweed, dandelion, ox-eye daisy and other plants.

CONTROL

Nicotine Sulphate.—The spraying of the infested plants with nicotine sulphate 40 per cent strength, has been found to be a satisfactory remedy for this insect. In the strength of one part of the nicotine sulphate solution to 400 parts of water, several investigators found this killed the eggs and larvæ and that a stronger mixture, namely, one part of the nicotine sulphate solution in 200 parts of water, destroyed the pupæ. In greenhouses in Canada where the nicotine sulphate 40 per cent has been used, control has been secured.

Spraying should begin as soon as injury is detected, and further applications, as necessary, made about a week or ten days apart. The undersides of the leaves should be sprayed as well as the uppersides.

The Violet Sawfly, *Emphytus canadensis* Kby.

In 1898, as reported by Fletcher in his annual report as Dominion Entomologist[1], the larva of this insect caused considerable injury to the foliage of violet plants in a large Toronto greenhouse. The outbreak was investigated by the senior author and a second visit to the same greenhouse was made in November, 1899. This, apparently, is the only record of this insect as a greenhouse pest in Canada. In the United States, there are several records of the insect being destructive in greenhouses.

[1] Rep. Ent. and Bot., Dom. Exp. Farms, 1898.

DESCRIPTION AND HABITS

The Egg.—According to Chittenden[1], the egg is small, whitish, soft and delicate. The eggs are laid singly, although a number may be present on the same leaf.

The Larva.—The larva at first is slightly less than one-eighth of an inch in length and in colour light slaty. It soon begins to feed on the leaf "cutting out little holes from the lower surface and later when more mature, eating along the edge of the leaf." When full grown the larva is about one-half of an inch in length, smooth and in colour bluish-black. In its later stages this false caterpillar is capable of causing serious injury to the plants.

The Pupa.—The pupa measures about 7.5 mm. in length and is nearly white in colour, the eyes turning darker as it approaches the time for final transformation. The change to pupa in the confinement of our rearing jars took place in the pith of sunflower stems placed there for the purpose. (Chittenden).

The Adult.—The adult sawfly with its wings spread is about one-half an inch in width; in length it is about five-sixteenths of an inch; the body is black. These sawflies have been collected outside in the Ottawa district in May and June.

Food Plants.—In the greenhouse, the only injury we have record of is to the violet. In the Ottawa district we have found the larvæ out-of-doors, feeding on garden pansies and violets. In years of abundance they have caused a good deal of harm, oftentimes completely destroying plants, in late June and the first half of July.

CONTROL

Tobacco Spraying.—In the Toronto greenhouse, the infested beds were sprayed with a solution made by soaking tobacco stems in warm water to which was added ivory soap. This solution we were informed controlled the outbreak. In the United States, Chittenden states that "extract of tobacco diluted at the rate of one part extract to thirty parts water was effective when applied as a spray, but florists are opposed to the use of tobacco on violets owing to its tendency to weaken the plants and to bring on the condition known as 'spot.' "

Other Remedies.—Under garden conditions, the late Dr. Fletcher recommended the dusting of the infested plants in the evening with white hellebore, or with Paris green mixed with fifty times its weight of common flour or some other dry diluent.

Fuller's Rose Beetle, *Pantomorus fulleri* Horn.

There are few records of this beetle causing injury in greenhouses in Canada In 1889, a serious infestation was investigated in an Ottawa greenhouse and this is referred to in the Report of the Dominion Entomologist for that year. It was noted that a number of different plants had been eaten by the beetles, as well as the roots of certain plants by the grubs. The beetle is nocturnal in habit, hiding in the daytime beneath leaves, etc. Injury, therefore, is effected chiefly during the night. The insect is unable to fly.

DESCRIPTION AND HABITS

The Egg.—Chittenden[1] states that "an individual egg measures about .9 mm. in length and about one-quarter that in width. It is smooth, soft, and of a pale translucent yellow. The normal form is ellipsoidal, but great variability occurs from the close compression of the eggs, as they are deposited in rows." The egg stage lasts about a month. On hatching the young grub at once enters the soil in search of food.

[1]Bull. 27, U.S., Bur. of Ent., U.S. Dept. Agr.

Fletcher in the report referred to above describes the larva and beetle as follows;—

"*The Larva.*—A thick white legless grub, when full grown one-fourth of an inch in length, the body curved, wrinkled above and flattened below, covered with short tawny bristles. Head yellow with dark, black-tipped, sharp mandibles, with which it consumes the young rootlets of various greenhouse plants."

"*The Beetle.*—The perfect beetle is a brown weevil a little more than one-fourth of an inch in length, with a short thick snout, and long slender antennæ or feelers, bent abruptly in the middle. The wing cases are indistinctly striate, and bear rows of large punctures and minute hairs. A whitish stripe runs along the sides of the thorax and half way down the sides where it terminates as an oblique white dash, reaching to the middle of each wing-case."

The grub and beetle are similar in appearance to the grub and adult of the Black Vine Weevil, (see fig. 20).

Food Plants.—In the Ottawa greenhouse the foliage of roses and lilies were specially attacked by the beetles and the roots of roses and begonias by the grubs. In other greenhouses in Canada the insect has attacked abutilon and plumbago. In the United States there are records of the insect feeding upon a number of other greenhouse plants.

CONTROL

In the report of the Dominion Entomologist referred to above, it is stated that the plants frequented by the mature beetles for feeding were syringed with a weak mixture of Paris green. The writers have had no opportunity to test the value of any measures suggested for the control of this insect. The hand picking of the beetles whenever seen should, of course, be practised, and the same destroyed by burning or otherwise. Possibly applications of tobacco dust to the soil as recommended for the Rose Midge would be useful, or protection afforded by adopting tanglefoot barriers as discussed under the Black Vine Weevil.

The Azalea Leaf-miner, *Gracilaria azaleae* Busck.

This species has occasionally been found on azaleas imported from Europe, particularly Belgium. In the United States, it has become established as a greenhouse pest undoubtedly having been introduced from Belgium and Holland. It has also been found on stock from Japan. We have no record of the insect breeding in any greenhouses in Canada but as it has become established in the United States, for instance in the states of New Jersey and New York, it may at any time become a pest of importance in our houses.

DESCRIPTION AND HABITS

The Larva or Caterpillar.—Felt[1] states that "the small, yellowish caterpillars, when nearly full grown, about one-fourth of an inch long, usually turn over the tip of an azalea leaf, webbing it down with fine silken strands and eating away the tissues of the infolding underside. The injured portion turns dry and the retreat contains numerous small black particles of frass."

The Moth.—"The parent insect is a delicate moth with a wing spread of only three-eighths of an inch. The forewings are yellowish, with large purplish areas and a series of purplish dots along the costal margin of the broad yellowish portion. The hind wings are slender, light pearly-gray and long-fringed."

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[1]29th Rep. State Ent., N.Y., 1913.

CONTROL

In the state of New Jersey, Weiss[1] states that in private greenhouses it is usually controlled by the removal of infested leaves by hand. In one large commercial establishment, the same author records that the spraying of infested plants with arsenate of lead paste in the strength of eight pounds to 100 gallons of water, gave good results. In New York state, Felt records that treatment with tobacco preparations either by fumigation or spraying appeared to be a very effective method of control.

The Strawberry Leaf-beetle, *Paria canella* Fab.

This insect has not, as yet, been reported as a greenhouse pest in Canada. During the last two or three years, however, it has caused serious injury to the foliage of roses in a number of commercial greenhouses in the United States. It is important, therefore, that attention be drawn to this insect as it occurs abundantly in the province of Ontario, and other sections of eastern Canada.

DESCRIPTION AND HABITS

The Larva or Grub.—The larva when full grown is about one-fifth of an inch long and in general appearance resembles a small white grub. It changes to the beetle state within an earthen cell.

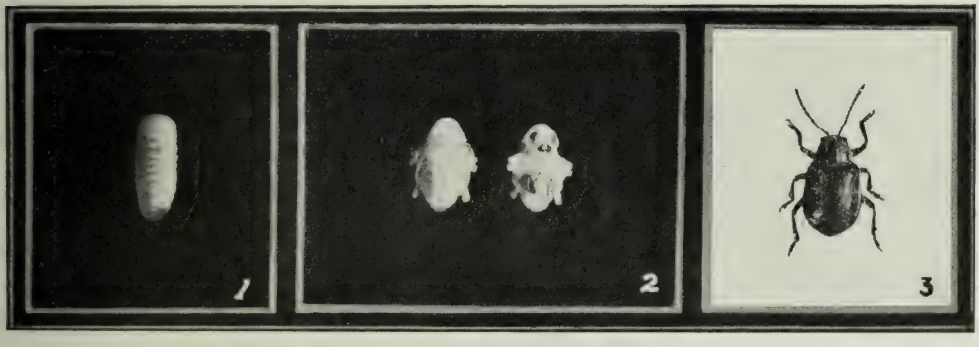


Fig. 10—The Strawberry Leaf-beetle; 1, larva; 2, pupæ; 3, adult beetle. All enlarged four times. (Original).

The Beetle.—The adult beetle is oval in shape and in length about an eighth of an inch. It varies in colour, some individuals being black, others yellowish-brown or brown. According to Weigel[2] the adults hibernate under mulch or other convenient shelter during the winter months. Florists have stated that "the beetles put in their first appearance about the latter part of May, or early in June, and reach their maximum numbers during July. Their feeding may continue throughout the month of August or even later. There may be several broods annually under glass." Feeding takes place at night. The foliage is "badly perforated and ragged, presenting a shot-hole appearance."

Food Plants.—As mentioned above this insect occurs commonly in eastern Canada and during some seasons the foliage of strawberries is much riddled; the grubs, too, have been found feeding on the roots of the same plants. Other

[1]Ent. News, XXIX, 114.
[2]Amer. Rose Annual, 1920.

plants attacked by the beetles are raspberry, apple, etc. In greenhouses, the only plant injured so far is the rose.

CONTROL

Weigel in the article referred to states that the best results in destroying the beetles were obtained by fumigating at night only with hydrocyanic acid gas.

Fig. 11—Strawberry leaves destroyed by Strawberry Leaf-beetle. (Original).

The Roadside Grasshopper, *Camnula pellucida* **Scudd.**

Grasshoppers are not considered as greenhouse pests. During 1921, however, the above species caused considerable injury to an important lettuce crop in a large greenhouse in the province of Alberta. The outbreak was investigated by Mr. H. L. Seamans, Entomologist in charge of the Dominion Entomological Laboratory, at Lethbridge, Alta.

According to report, the owner of the greenhouse introduced a large quantity of soil into his houses in early spring. The neighborhood had been devastated by the Roadside Grasshopper and large numbers of eggs of the species had been deposited in the soil used. The eggs hatched in the greenhouse in the first half of April and the young hoppers at once attacked the lettuce plants riddling the leaves to such an extent as to render the plants unsaleable.

CONTROL

Prompt applications of the well known poisoned bran mixture (page 20) soon controlled the infestation.

SUCKING INSECTS

The Greenhouse White Fly, *Trialeurodes vaporariorum* **West.**

The greenhouse white fly has very general feeding habits and attacks a great variety of plants Among its preferred food plants are the following: tomato, cucumber, lettuce, pelargonium, salvia, ageratum, lantana, heliotrope, fuchsia, hibiscus, abutilon, solanum, cigar plant, primula and schizanthus.

DESCRIPTION AND HABITS

The Egg.—The females deposit their eggs on the undersides of tender leaves. The egg is very small, irregularly ovoid and in colour is light green or yellowish-green, becoming darker before hatching. It is attached to the leaf by a short

stalk. The eggs hatch on an average in about 12 days. Under laboratory conditions, the incubation period of eggs kept under observation varied from 12 to 17 days, the average being about as stated The number of eggs laid by individual females in these experiments varied from 16 to 158, the average being 88.

The Larva or Nymph.—The nymph is flat in shape, oval in outline, and pale greenish in colour. The newly hatched young move about for a short time and then insert their beaks in the leaves and become stationary. They are sucking insects feeding greedily on the plant juices and in about four weeks time, after passing through four stages, transform to adults. The last stage nymphs are armed with white waxen filaments which radiate from the body. The duration of the nymphal life in experiments with 52 nymphs varied from 21 to 42 days, the average being 29 days.

Fig. 12—White-Fly; adults and nymphs; enlarged four times. (Original).

The Adult.—The perfect insect is a small four-winged moth-like creature about one-sixteenth of an inch long, the wings being pure white in colour and the body yellowish. Like the nymphs they feed on the undersides of the leaves. The length of life of six females kept in confinement varied from 18 to 68 days, the average being 40 days, the period of egg-laying ranged from 7 to 58 days, the average being 33 days. Severely attacked leaves dry up and die. Infested plants become covered with a sticky liquid which is excreted by the insects and in which very frequently a sooty fungus develops.

CONTROL

Fumigation.—Fumigation with hydrocyanic acid gas (described on page 7) is the remedy commonly adopted by florists. The strength of the cyanide necessary will depend upon the tightness of the house. For tight greenhouses the initial dose should be one-eighth of an ounce of sodium cyanide (128%) for each 1,000 cubic feet of space.

Soap Solutions.—Whale oil soap is useful for destroying the white fly and should be used in the strength of one and a half ounces to one gallon of water. The spray kills by contact and should, therefore, be directed to reach the undersides of the leaves where the insects are clustered as only those which are actually hit by the spray will be killed. The unpleasant odour of whale oil soap is

objectionable to many lovers of ornamental plants. Ivory soap has also been used by some growers in the strength of one pound dissolved in six gallons of water. Several applications a week or so apart may be necessary.

Scale Insects

Among the sucking insects which commonly infest greenhouse plants are several species of scale insects. They are found on various kinds of house plants, more frequently, however, on such plants as ferns, palms, oleanders, etc. Ferns taken in as "boarders" are almost invariably infested with scale insects.

The following are well known greenhouse species:—

The Soft Scale, *Coccus hesperidum* Linn. This is a soft, oval, slightly convex, brownish species, about one-eighth of an inch in length, and occurs on such plants as oleanders, citrus plants, bay trees, etc. It is one of the larger of the scale insects found in greenhouses.

The Hemispherical Scale. *Saissetia hemisphericæ* Targ., is also a large brown species and in general is similar to the Soft Scale, hemispherical in shape and frequently a pest of ferns, crotons, palms and orchids.

The Oleander Scale, *Aspidiotus hederæ* Vall., is a common greenhouse species. It is circular, nearly flat, about one-sixteenth of an inch in diameter and in colour is whitish or light gray. It infests palms, oleanders, crotons, dracena, acacia, ivy, etc.

The Circular Red Scale, *Chrysomphalus aonidum* Linn., is frequently abundant on palms, rubber plants, oleander, etc. It is about one-sixteenth of an inch in diameter, circular and slightly convex in shape; dark purplish-brown in colour with a nearly central nipple-like prominence.

The Fern Scale, *Hemichionaspis aspidistræ* Sign., or as it is erroneously called "the stationary white fly" commonly infests Boston ferns and allied varieties, and *Pteris* sp. The male scale is white (hence the name "white fly") tricarinate and roughly rectangular in shape. The female scale is pale brown, inconspicuous and somewhat pear-shaped. The male scales are invariably more abundant than the females.

HABITS AND LIFE-HISTORY

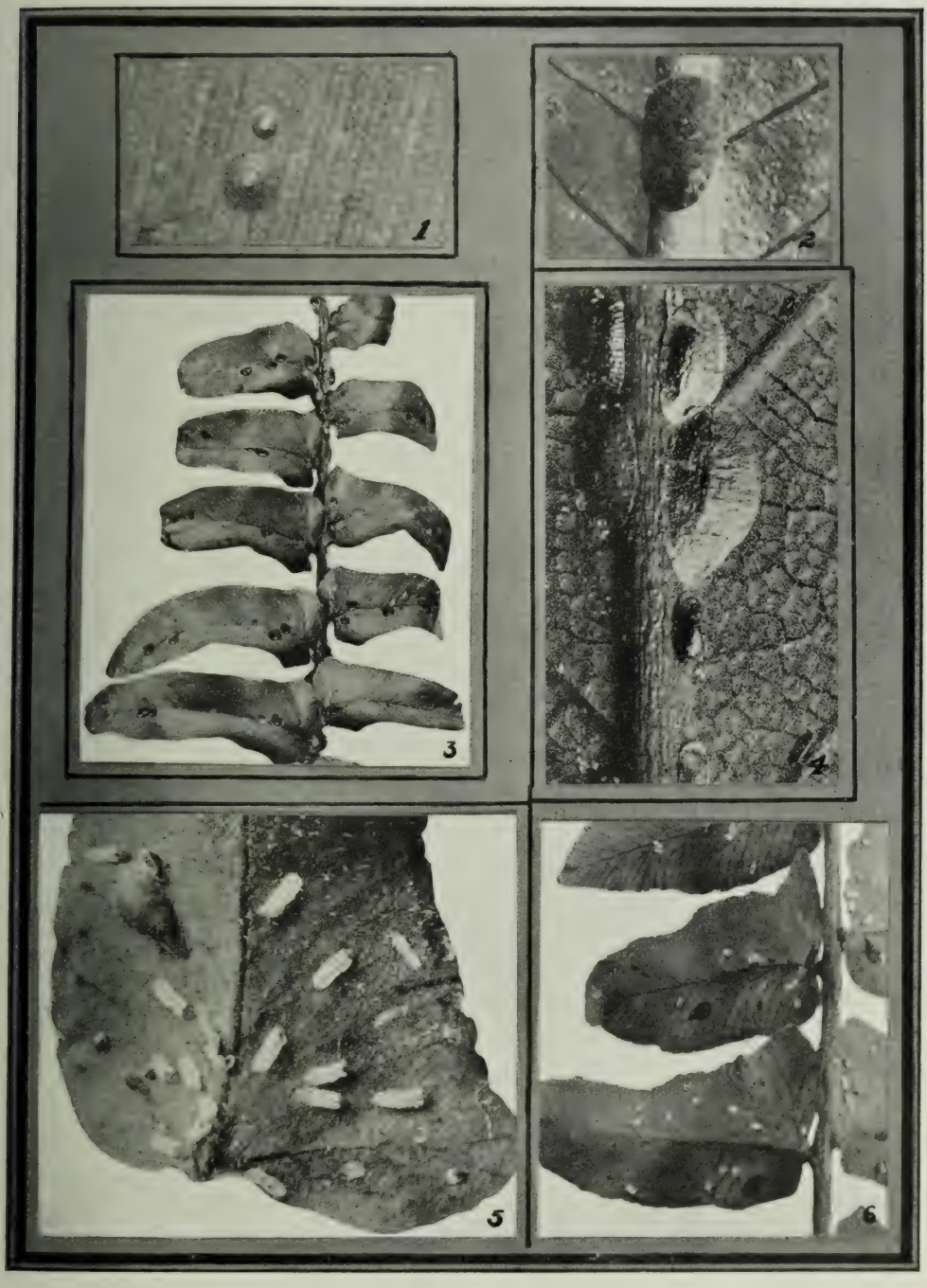
All the scale insects mentioned above with the exception of the Soft Scale reproduce by means of eggs which are deposited beneath the scale. The female of the Soft Scale on the other hand gives birth to living young. The newly hatched or newly born larvæ, as the case may be, crawl around for a short time, then settle down on the leaves or bark, insert their sucking mouth parts and feed on the juices. They cover themselves with a waxy material which forms the scale or covering. The females remain stationary thoughout their lives. The males on the other hand when they become mature acquire wings, emerge from their scale coverings and fly around and fertilize the females. The mature males are minute two-winged insects.

CONTROL

The safest and most generally used method of combatting scale insects is sponging with soap suds.

Scale insects may also be kept under control by spraying the plants with common laundry soap, a quarter of a pound to each gallon of water, or with a 40 per cent nicotine extract, 1-400 to which a little soap has been added. It is advisable, especially in the case of ferns, to wash off the spray material about two hours after it is applied. In houses where only a few plants such as oleanders, or strong-leaved ferns are infested, they may be washed with such a soap mixture by means of a soft brush or cloth, or the plants may be inverted and the stems

PLATE II.



SCALE INSECTS.

Fig. 1—Circular Red Scale on palm leaf, much enlarged; 2, Hemispherical Scale on croton, much enlarged; 3, Hemispherical Scale on Boston fern; 4, Soft Scale, much enlarged; 5, Fern Scale, males, females and young, much enlarged; 6, Fern Scale, about natural size. (Original).

and leaves thoroughly doused in a pail containing the soapy mixture. If a piece of cloth is held tightly around the base of the plant, the earth in the pot will be prevented from falling into the pail. Two or three applications a week apart may be necessary.

As scale insects flourish to best advantage in a dry atmosphere, palms, rubber plants, ferns and crotons, should be frequently syringed with water and should be kept under humid conditions. It has been observed in the case of the Fern Scale, *H. aspidistræ*, that this insect is of no importance in humid fern houses, and only becomes troublesome on plants kept in a dry atmosphere, such as one finds in houses, stores and halls.

Mealy Bugs

Mealy bugs rank among the most troublesome pests with which the florist has to contend. They are closely related to the scale insects and may be found on house plants in any season of the year. Two species commonly occur in greenhouses—the Common Mealy Bug, *Pseudococcus citri* Risso, and the Long-tailed Mealy Bug, *P. longispinus* Targ.

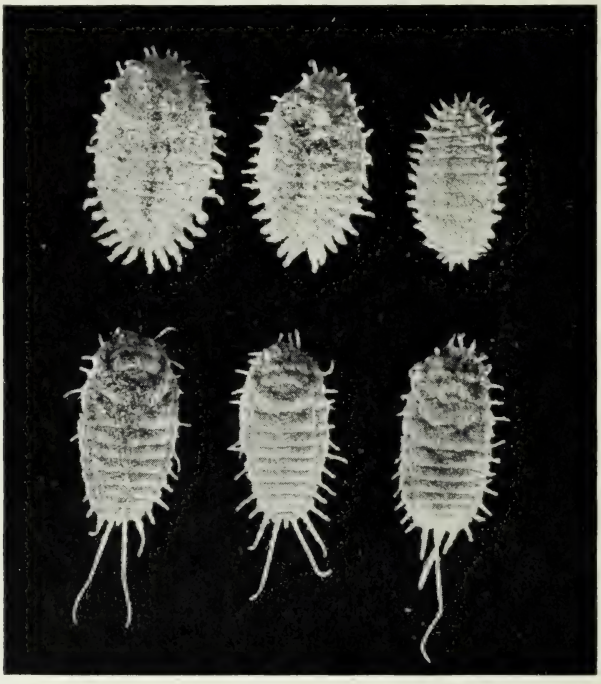


Fig. 13—Mealy Bugs; upper figures, Common Mealy Bug; lower figures, Long-tailed Mealy Bug. All enlarged about ten times. (Original).

DESCRIPTION AND HABITS

The two species, though very similar in appearance, can be readily separated. The Common Mealy Bug has very short caudal or "tail" filaments, whereas the Long-tailed Mealy Bug, as its name indicates, has long filaments—frequently longer than the insect's body.

The female of both species is about one-sixth of an inch in length, broadly oval in shape, brownish in colour and is covered with a more or less dense, white waxy material which, along the lateral margin, takes the form of conspicuous projecting filaments. The larvæ or immature stages resemble the female. The male when mature is a small, delicate, two-winged fly.

The female of the Common Mealy Bug deposits a large number of small yellowish eggs in a mass, which is completely encased in a white flocculent secretion. Each female is capable of laying from 300 to over 500 eggs. The female of the Long-tailed Mealy Bug does not deposit eggs, but gives birth to living young.

The bugs occur in masses on the tender shoots and on the under and upper-sides of the leaves and on the petioles. Individuals of all sizes may be found on the plants at the same time, especially on the undersides of the leaves along the mid-ribs and near the base of the leaf stems. They injure the plants by extracting the sap, in extreme cases causing the foliage to turn yellow and drop prematurely. Infested plants are also rendered unsightly by the disgusting masses of insects and by the presence of a sooty fungus which grows in a sweet sticky liquid called honey dew which is excreted by the bugs.

Food Plants.—Mealy bugs infest a great variety of plants; among others: coleus, fuchsia, citrus, heliotrope, geraniums, oleander, bougainvillea, orchids, poinsettia, crotons, passiflora and cyperus.

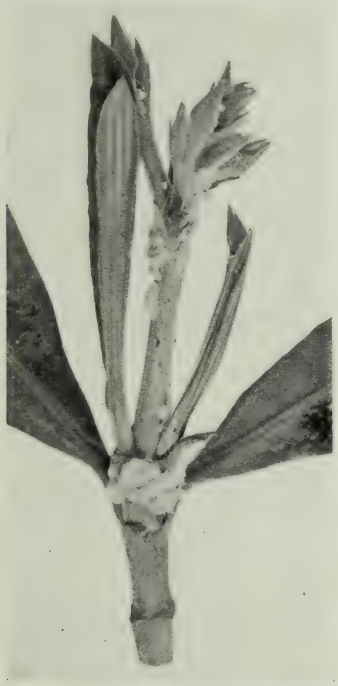


Fig. 14—Mealy Bugs; egg masses and nymphs on Bougainvillea. (Original).

CONTROL

The cheapest, safest and most simple method of combating mealy bugs is to take the infested plants out-of-doors, place them on the ground and forcibly wash off the insects with water. Each plant should be treated individually and good pressure should be used. Sponging and brushing with soapy water are remedies which should be resorted to only when forcible sprinkling is impracticable.

Fumigation with hydrocyanic acid gas as used under greenhouse conditions is practically useless. Kerosene emulsion, one part of the stock solution to thirty parts of water will destroy the bugs but is liable to seriously injure the plants.

The Greenhouse Orthesia, *Orthesia insignis* Doug.

This insect is closely allied to the common mealy bugs. It is a pest of wide distribution and attacks a variety of plants grown indoors.

DESCRIPTION AND HABITS

The adult female is about 1.5 mm. long; in colour it is usually of a dark green shade, older individuals being blackish; the body is covered with snow-white waxy plates. The males are smaller. There are several generations of the insect in the year. Different stages may be present at the same time. The female carries her eggs in a white egg-sac which is fastened to the posterior end of the body. The insect feeds by sucking the juice from the plants.

Food Plants.—Coleus, amaranthus, lantana, chrysanthemum, ageratum, and a number of other plants are freely attacked.

CONTROL

The forcible washing of infested plants with water as recommended for mealy bugs is equally applicable for the Greenhouse Orthesia.

Fig. 15—1, Aphids on snapdragon; 2, aphid parasitized by *Aphidius* sp., note the exit hole from which the parasite emerged; 3, wingless aphid; 4, winged aphid; figures 2, 3 and 4 much enlarged. (Original).

Aphids or Plant Lice

Every florist is familiar with aphids or plant lice—the so-called "green flies" and "black flies" which infest a great variety of plants and which are generally present in all greenhouses in greater or less numbers at all times of the year and against which a perpetual warfare has to be waged.

DESCRIPTION AND HABITS

Several species are commonly troublesome—most of them are green in colour and others again are reddish, brown or black. They are soft-bodied,

oval or globose insects with sucking mouth parts, conspicuous antennæ (feelers) and long legs. They are easily distinguished from all other greenhouse insects by the possession of two tube-like structures called cornicles which project from the sides of the abdomen near the posterior end. The adults may possess two pairs of transparent wings or they may be wingless.

Aphids feed on the tender growth of plants and by withdrawing the life juices distort the foliage and young shoots and in extreme cases partially or wholly destroy the plants. Their presence on plants is frequently indicated by a curled and distorted condition of the leaves. They may also infest and seriously injure the flowers.

They have marvellous powers of multiplication. They reproduce parthenogenetically, that is, without the intervention of a male and they give birth to living young. As they may commence to reproduce seven to ten days after birth and as each female may produce over fifty young, it is not at all surprising that frequently the plant lice become so numerous that it is almost impossible to insert a pin into the infested portion of a plant without touching an insect. Both winged and wingless forms are produced. The function of the winged forms is to migrate to fresh plants and establish new colonies.

SOME COMMON GREENHOUSE SPECIES

The Green Peach or Spinach Aphis, *Myzus persicae* Sulzer, is undoubtedly the most common greenhouse species. It is a very general feeder and attacks a great variety of plants—among others carnations, snapdragon, easter lilies, cinerarias, primula, vinca, chrysanthemums, radish and other vegetables. It is greenish in colour and has clubbed cornicles.

The Lily Aphis, *Myzus circumflexum* Buckton, infests easter lilies, callas, arum lilies, vinca, tulips, freesia, hydrangea, maidenhair fern, chrysanthemums, cyclamen, schizanthus, etc. It is greenish-yellow with conspicuous black markings on the abdomen, which in the case of the wingless females are shaped like a horseshoe.

The Melon Aphis, *Aphis gossypii* Glov., feeds on cucumbers, other curcurbits, begonias, etc. It varies in colour from pale to dark green and has short dark cornicles.

The Rose Aphis, *Macrosiphum rosae* Linn., as the name indicates, attacks the rose. It is a large green species with conspicuous black cornicles.

Two species commonly occur on chrysanthemums, the Black Aphis, *Macrosiphoniella sanborni* Gill., which has short bottle-shaped cornicles and "the small green fly" *Rhopalosiphum rufomaculata* Wilson.

The Pea Aphis, *Macrosiphum pisi* Kalt, a large, shining green species, with long cornicles, commonly infests sweet peas.

The Black Violet Aphis, *Micromyzus violiae* Perg., occurs on and is frequently very injurious to violets. It is a dark coloured insect with light brown appendages, and with broad black wing veins.

CONTROL

Aphids are easily controlled by spraying with nicotine preparations or by fumigating with tobacco extracts or hydrocyanic acid gas. The general practice should be to spray when only a few plants are attacked and to fumigate where most or all of the house is infested. In using the commercial tobacco extracts the manufacturer's directions should be followed.

In combatting the violet aphis, hydrocyanic acid gas should be used as nicotine is liable to injure violet leaves.

Some growers prefer to fumigate with hydrocyanic acid gas because it is cheaper than nicotine preparations; however, the majority fumigate with tobacco because it is safer.

Violets are very susceptible to injury from tobacco fumigation and nicotine sprays. Commercial violet growers, therefore, regularly use hydrocyanic acid gas for the control of plant lice. One large commercial firm in Ontario uses a little more than one-eighth ounce of sodium cyanide to each 1,000 cubic feet of space in a violet house (lapped glass) and this strength controls aphids and causes no injury.

Thrips

With the exception of aphids there are no insects which are more generally injurious to plants grown under glass than thrips. The chief species found in greenhouses are the Onion Thrips, *Thrips tabaci* Lindeman, a most troublesome species; the Greenhouse Thrips, *Heliothrips haemorrhoidalis* Bouche; the Sugarbeet Thrips, *Heliothrips femoralis* Reuter, and the Black Clover Thrips, *Haplothrips statices* Haliday. As the habits of these species are, in general, similar and the remedies used in combatting them practically the same, they can, conveniently, be treated as a class.

Fig. 16—Rose buds destroyed by thrips. Adult thrips below, much enlarged. (Original).

DESCRIPTION AND HABITS

Thrips are minute, elongate insects and the species which commonly infest greenhouse plants are yellowish, yellowish-brown, brown or black in colour. The adults are easily distinguished from the nymphs or immature insects by the possession of two pairs of narrow wings fringed with long, delicate hairs.

They attack the foliage and flowers, and by rasping the tissues and extracting the sap and colouring matter, produce a speckled silvery effect. Badly injured leaves soon become discoloured, gradually wilt and die.

The life-history of a species which we have found most troublesome in greenhouses, namely, the Onion Thrips, is, briefly, as follows:—

The female has a tiny saw-like organ called an ovipositor near the posterior end of the abdomen and by means of this she makes slits in the leaf or stem and inserts minute, white eggs in the tissues. The eggs hatch in a few days and the nymphs or immature thrips soon commence to feed. The nymphs pass through four stages; the first two on the plants and the last two in small earthen cells in the soil. They transform to adults while in the soil and in this latter stage return to the plant and proceed to feed and breed. The life cycle is completed in three to four weeks.

An account of the Greenhouse Thrips has been published by H. M. Russell[1]. From this the following statements have been taken. The female deposits her eggs within the leaf tissue and these hatch in the greenhouse in about eight days. The larvæ which hatch from the eggs are minute, white in colour, and feed together in colonies on the surface of the leaf removing the colouring matter in the same manner as do the adults. Upon becoming full grown the nymph, or larva, changes to the resting stages (prepupa and pupa) during which time it remains more or less motionless and does not feed. These stages require periods of about four to six days, after which the adults emerge. The total time required for this insect from the time the egg is laid until the adult emerges ready to reproduce its kind is from twenty to thirty-three days, and as this insect continues active in the greenhouse the entire year many generations occur each year.

Food Plants.—Roses, carnations, cucurbits, calla lilies, cinerarias, fuschia, azalea, chrysanthemum, phoenix and other plants are frequently seriously damaged by these insects.

CONTROL

There are at least three good remedies for thrips:—

(1) Fumigation with any of the standard nicotine extracts. (See page 10).
(2) Hydrocyanic acid gas fumigation. (See page 7).
(3) Spraying with a mixture composed of two tablespoonfuls of Paris green, two lbs. of brown sugar and three gallons of water.

This spray should be applied in a form of a mist. Some growers claim that this is the most effective method of controlling thrips.

It should also be mentioned that spraying with nicotine extracts is effective provided the work is done very thoroughly and that even forceful syringing with water tends to hold thrips pretty well under control.

Fig. 17—Tarnished Plant Bug; adults enlarged about three times. (Original).

The Tarnished Plant Bug, *Lygus pratensis* L.

This common plant bug known, also, to the florist and gardener as the aster bug, is frequently very destructive in greenhouses to certain kinds of plants. In the flower garden it is troublesome almost every season destroying the buds of dahlia, zinnia, etc.

DESCRIPTION AND HABITS

The Egg.—The egg is described by Crosby and Leonard[2] as being "·95 to 1 millimeter in length by .25 millimeter in width, flask-shaped, obliquely truncate, and at the anterior end slightly curved and compressed toward the apex." We have no records of the eggs having been deposited on plants in the greenhouse.

[1]Cir. No. 151, U.S. Bureau of Entomology.
[2]Bull. 346, Cornell Univ. Agr. Exp. Station.

The Nymph and Adult.—The bug has five immature or nymphal stages, and in these stages it is mostly green or yellowish-green in colour. In the adult or perfect stage it is about one-quarter of an inch long, of a variable colour, most individuals being probably of a light brown colour with black and yellowish markings. In this stage it has fully-developed wings. It is a true sucking insect and both in the nymphal and adult stages is very active and wary. The winter is passed in the adult stage out-of-doors, under fallen leaves, stones, rubbish, etc. In the spring the insects emerge and feed and breed on various cultivated plants and on weeds throughout the growing season. They gain entrance into greenhouses through open doors and also probably through the ventilators.

Food Plants.—The Tarnished Plant Bug is known to attack a great many different kinds of cultivated plants. In the greenhouse during some years it effects important injury to such plants as chrysanthemums, dahlias, carnations and asters, producing what has been called blind buds, by puncturing the blossom buds with its sucking mouth parts. In the case of single-stemmed chrysanthemums this is a serious injury,

CONTROL

Clean Culture.—Areas adjacent to greenhouses which are kept clean of weeds, rubbish, etc., will not attract the insects as will plots and gardens which are allowed to become dirty.

Screening.—The bugs may be prevented from gaining access to plants in greenhouses, by the placing of wire cloth screens on the doors and ventilators. If it is not considered practicable to screen the ventilators, the doors at least should be screened.

Tobacco Fumigation,—One large grower in Ontario reports success in controlling the bugs by fumigating with tobacco three or four nights a week up to the time the chrysanthemums come into bloom. This, it is claimed, kills the nymphs and stupifies the adults to such an extent that they are easily caught and destroyed.

Dust Mixtures.—Preliminary experiments, which were conducted in 1919 with dust mixtures applied by means of a hand blower, indicated that heavy applications of hydrated lime alone and of a lime-nicotine dust[1], containing 5 per cent nicotine-sulphate, are of value in repelling the Tarnished Plant Bug. Both of these dusts are certainly worthy of a trial. In applying the lime-nicotine dust in greenhouses, it would be advisable for the operator to wear a cheap respirator on account of the choking effect of the nicotine fumes.

According to the Ontario Vegetable Specialist, a dust composed of 20 pounds copper sulphate, 20 pounds sulphur, 30 pounds lime and 30 pounds tobacco dust has proved to be very effective in controlling the Tarnished Plant Bug on celery. For greenhouse work, a mixture composed of 70 pounds lime and 30 pounds tobacco dust would no doubt be more suitable than the foregoing.

BORING AND ROOT-DESTROYING INSECTS

The Rose Midge, *Dasyneura rhodophaga* Coq.

In the report of the Dominion Entomologist for the year ending March 31, 1915, a brief mention is made of the occurrence of this pest at London, Ont., specimens of the infested shoots of the variety Mrs. J. Laing having been received at Ottawa in July, 1914. This was apparently the first record of the Rose Midge in Canada. Two years later its presence was detected in greenhouses in Toronto. Its work was first noticed in these houses in September, 1916. The buds of the young shoots did not develop and on investigation it was found that they were being destroyed by the larvæ. The varieties of roses which

[1]Lime-nicotine dust may be purchased from insecticide dealers.

had been severely injured were Ophelia, Milady and Stanley. The variety Richmond was very slightly attacked. The owner of the houses was of the opinion that the pest was introduced on rose bushes imported from Chicago, Ill. It has since been found in other places in Ontario.

As the Rose Midge is one of the worst known pests of roses (see plate III, fig. 4), florists in Canada should realize the danger of its being introduced into their houses. In 1919 it was estimated that this insect caused a loss of $12,000, in one Ontario greenhouse, and in another a loss of $6000.

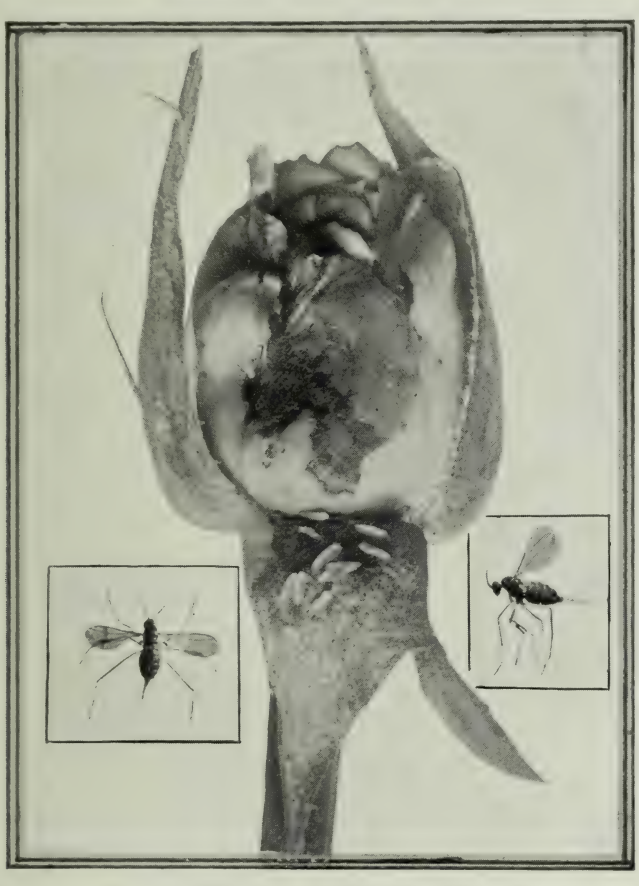


Fig. 18—Rose Midge larvæ in flower bud; adult female Rose Midge below, from two views. All much enlarged. (Original).

DESCRIPTION AND HABITS

The Egg.—(Plate III, fig. 3.) This is yellowish in colour and so small as to be hardly visible to the naked eye. The female deposits her eggs between the folded leaves of the leaf buds and to some extent in the axils of tender leaves and between the sepals and petals of the blossom buds. Under greenhouse conditions the eggs hatch in about two days,

The Larva or Maggot.—(Plate III, fig. 3.) The whitish maggots on hatching at once begin to destroy the terminal leaves and blossom buds. When abundant they may be found feeding on any succulent part of the rose plant, as for instance at the base of the flower buds, within the buds, on the uppersides of tender leaves and on leaf petioles. The favourite and usual point of attack is on the young shoot in the axil of a leaf petiole. Infested shoots grow crooked, and, as a

general rule, wither and die. Affected flower buds when not killed outright may be so disfigured as to be unsaleable. In from five to seven days the maggots become mature and then leave the plant, dropping to the soil where they change to the pupal state and emerge as adult flies in about six days. In the mature stage the maggots are tinged with red.

The Adult.—The perfect insect, or midge, is two-winged, yellowish-brown in colour and less than one-twentieth of an inch in length. Soon after the adults appear the females deposit eggs for the next generation.

The midge is most abundant and destructive during summer. With the coming of autumn it declines in numbers and by November wholly disappears from the rose plants. It remains dormant in the soil throughout the winter months and does not reappear again until early March. It is fortunate for the florist that the insect remains quiescent in the soil during the winter months, when the most profitable crops are grown. Nevertheless, the winter crops must suffer as a result of the check the infested plants receive in the summer and fall.

Varieties Attacked.—In the garden at London, Ont., hybrid teas and hybrid perpetuals were attacked, Mrs. J. Laing being the most severely injured. H. P's, however, with strong terminal shoots like those of Killarney have been practically immune. In greenhouses, Ophelia, Columbia and Milady are by far the most susceptible varieties; Russell, Stanley, Ward, Richmond, Shawyer, Hoosier Beauty, Sunburst, are attacked to some extent and here again Killarney appears to be practically immune. In the United States besides the varieties mentioned, the following have also been attacked: Radiance, Hadley, American Beauty, Uncle John, Joe Hill, Kate Moulton, Bridesmaid, Liberty, Meteor, Madam Chatenay, Ivory, Golden Gate, Wooten, La France and Duchess of Albany[1].

CONTROL

Tobacco Fumigation and Destruction of Infested Buds.—In the Toronto houses where the pest was discovered in 1916, tobacco fumigation and the pinching off and destruction of all infested buds has been practised. At first the houses were fumigated during a period of three or four weeks in spring and again whenever the midge became troublesome. This method, however, did not effectively control the insect and in 1919 the infested houses were fumigated with tobacco every other night from early April until the end of October. This kept the pest down to insignificant proportions all season and as a result no damage worth mentioning was effected. The disadvantages of this remedial measure are: (1) that in districts where tobacco stems are not easily procured and where commercial nicotine preparations would have to be used, it is very costly; (2) that it does not wholly eradicate the pest; and (3) according to some florists frequent fumigations stunt the growth of the plants.

Tobacco Fumigation and Application to Soil of Tobacco Dust.—In 1916, Messrs Sasscer and Borden[2], of the United States Bureau of Entomology, having determined by cage experiments that a covering of tobacco dust on the rose beds would prevent the full grown larvæ from entering the soil, conducted the following experiment in a midge-infested house in Maryland. All the rose beds were covered on October 12, 1916, with tobacco dust averaging from one-fourth to one-half inch deep. To prevent the larvæ from entering the dirt walks of the houses, all the walks were sprayed with kerosene emulsion.[3] Simultaneously, nightly fumigation with tobacco stems was begun and continued until October 30, from which date until November 8, the houses were fumigated every other night. The object of this fumigation was to kill the adult midges before the eggs were deposited. The results secured from this experiment were excellent—the midge was practically eradicated.

[1]Sasscer and Borden, Bull. 778, U. S. Dept. Agr.
[2]Bull. No. 778, U.S., Dept. of Agr.
[3]The method of making kerosene emulsion is described on page 7.

Application to Soil of Tobacco Dust Alone.—Following the experiments conducted in Maryland, referred to above, we tested the value of applications to soil of tobacco dust alone, in greenhouses in Ontario and we had undoubted evidence that a coat of tobacco dust would not only kill the maggots which dropped from the plants but also that the nicotine absorbed by the soil from the dust would destroy the midge pupæ and larvæ in the soil. In short, our experiments indicated that in combating the midge it was not necessary to supplement the soil treatment by nightly fumigation with tobacco. In view of the cost of such nightly fumigations, the importance of this discovery is apparent. Since these preliminary experiments were conducted, we have demonstrated under large greenhouse conditions that the insect can be completely controlled by applications to soil of tobacco dust alone. In one establishment where we directed this work thirty-five tons of dust were used. This work was done in mid-August. The fallen leaves on the beds were removed and the surface of the soil made as smooth as possible. The beds were then thoroughly drenched with water and a coat of tobacco dust one-fourth to one-half inch thick was applied, great care being taken to cover all parts of the beds. As an additional precaution all the walks were sprayed with kerosene emulsion in order to kill any maggots which might have fallen from the plants to the walks.

From the results obtained in the above establishment as well as in other greenhouses in Ontario, we have no hesitation in recommending the tobacco dust treatment for the Rose Midge. Equally good results were obtained in houses where the soil was treated either in mid-July, mid-August, or September.

PREVENTION

In order to prevent the further spread of this insect, and this at present is a very important object, florists should be guided by the following recommendations:—

(1) Whenever possible, growers should propagate their own roses.

(2) New stock should be obtained from non-infested greenhouses.

(3) Rose plants and scions purchased through commission houses or from places not known to be free of midge, should be imported before the end of February. This recommendation is made because such stock, provided it has been planted in November or December, will not have been exposed to infection.

(4) Greenhouse-grown roses, brought in later than February, should be carefully examined for Rose Midge injury, and any infested plants should be destroyed. In addition to this, the soil should be washed off the roots of the plants and should then be thrown into the furnace or scalded with hot water or steam.

The Chrysanthemum Midge, *Diarthronomyia hypogaea* H. Lw.

In 1915, the Chrysanthemum Midge was found to be thoroughly established in a large greenhouse at Ottawa. It had undoubtedly been introduced on some chrysanthemum plants imported from the United States. In addition to the Ottawa infestation we also received in the same year, infested material from a florist in Victoria, B.C. This last infestation was first noticed in August, 1915, on chrysanthemums growing outside as well as within the greenhouse.

Since 1915 the insect has become pretty well established throughout the province of Ontario and it has also been found in greenhouses in the provinces of British Columbia, Quebec and Nova Scotia. In the United States, too, its recent spread has been rapid and it is now reported from California, Connecticut, Delaware, District of Columbia, Georgia, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Oregon, Pennyslvania, Rhode Island, South Dakota, Tennessee and Virginia.

The Chrysanthemum Midge is of European origin.

PLATE III.

THE CHRYSANTHEMUM MIDGE, *Diarthronomyia hypogæa* H. LW., AND THE ROSE MIDGE, *Dasyneura rhodophaga* COQ.

Fig. 1—Galls on leaves of a chrysanthemum, resulting from the attack of the Chrysanthemum Midge; 2, Chrysanthemum Midge, much enlarged; 3, Egg, larva and puparium of the Rose Midge; 4, showing rose bud destroyed by larvæ of the Rose Midge. (Figs 1, 2 and 4 after Gibson; 3, redrawn after Webster).

DESCRIPTION AND HABITS

The Egg.—The egg is very small and reddish orange in colour. Measurements of ten eggs gave the following average: length ·275 mm., width ·079 mm. A female midge kept under observation at Ottawa was most active, running about on the new leaves, the favourite places chosen for egg-laying being the leaf hairs near the crevices between the young forming leaves. Eggs were also found near the tip of another plant, along the surface of the leaf among the leaf hairs. On one occasion (Oct. 27, 1916), in an Ottawa greenhouse, a string of extruded eggs was found attached to a dead female which had not been able to free itself from the gall and other eggs laid among the leaf hairs were present on the gall. Altogether forty-four eggs were counted. From observations recently made at our Vineland Entomological laboratory, an assistant, Mr. W. P. Garlick, made the following notes:—

"The eggs are laid by the female usually within the space of a few hours after emergence. They are deposited to some extent on expanded leaves, petioles and lateral buds, but most of them are laid between the petioles of the unexpanded leaves of the terminal buds. They are frequently numerous enough to give a distinct reddish colouration to the parts of the plant on which they are laid. Under greenhouse conditions, the average period of incubation of six lots of eggs was three and one-third days, the minimum and maximum being respectively two days and four days."

The length of the egg stage is stated by Weigel and Sandford[1] to vary from three to sixteen days. Females dissected during our studies, gave counts of from 128 to 156 eggs per female.

The Larva.—The larva or maggot is very similar to that of other cecidomyiids; in colour it is yellowish, or yellowish-orange; in shape plump, rounded at either end, the segments being distinct; in length about 1 mm. The above mentioned authors state that the maggot upon hatching moves about on the surface among the plant hairs for a period of from one to three days, preparatory to boring into the tissues. As a result of this attack an irritation is produced which results in the production of swellings or galls on the plant containing the developing maggots and pupæ. This attack may occur commonly on various portions of the chrysanthemum plants. In the Ottawa greenhouse the galls were abundant on the leaves, stems and buds. The galls at one time were so abundant on some young plants as to entirely deform them, as a result of which development was largely stopped and no flowers borne. Many single-stemmed plants showed conspicuous malformation of the stem, resulting from early attack of the insect. In material received from British Columbia the galls were found freely on the stems and leaves. On some of the terminal leaves, the presence of the insect in conspicuous numbers had prevented growth and the leaves were clumped together in more or less rosette fashion. As a general rule there is only one larva in each gall, but occasionally compound galls with two or three compartments are found with a larva in each compartment.

The Pupa.—When the maggot becomes mature it changes to the pupal state within the gall. The pupa is about 1.25 mm. in length; the abdomen is whitish or pale yellowish; thorax and wing-covers pale yellowish-brown, cephalic horns distinct, eyes showing black; leg-cases whitish or pale yellowish.

The Gall. (Plate III, fig. 1).—This is a conspicuous oval-shaped swelling in length from about 2 mm. to 2.5 mm. It is often slightly paler than the colour of the leaf or stem upon which it occurs, but on some plants particularly on the stems, it is concolorous and inconspicuous. In our experiments from 13 to 16 days elapsed from the time the eggs were laid until the appearance of the galls (average 14 1-3 days). After the flies have emerged the galls are more readily seen, particularly on the older leaves, owing to their having turned yellowish or whitish in colour.

[1]Bull, No. 833, U.S., Dept. of Agriculture.

The Adult, (Plate III, fig. 2).—The midge is a small two-winged fly, the average length of the body of seven male individuals measured 1.61 mm. and six females, 2.19 mm. The wings are transparent, the margins being light yellowish. The body is mostly of an orange colour, the legs yellowish.

Observations made at our Vineland laboratory indicated that most of the midges emerge from the galls in the small hours of the morning, very few being seen to issue after 9. a.m. The duration of the life-cycle from egg to adult of specimens kept under observation, varied from 29 to 44 days.

Food Plants.—In the Ottawa greenhouses all varieties of chrysanthemums were seemingly attacked. A large number of different varieties were being grown and the kinds which were noted to have been most freely attacked are the following: Chrysolora, Naomah, Radoelii, Ramapo, Hortus Tolsoms, Mrs. Clay Frick, December Gem, Madam G. Rivol, Dr. Engluehard, Anna, Pacific Supreme, Early Snow, Elberon, Ursula Griswold, Aesthetic and Etherington. The varieties Bob Pulling, Gertrude Peers, Daily Mail, Oconta, Mrs. G. C. Kelly, W. Wood Mason, F. T. Quilleton, and E. T. Quittington were fairly free from injury. In addition, in other Ontario greenhouses Major Bonnaffon has been completely destroyed and other varieties attacked were: White Chieftain, Bronze Brighthurst, Celtic, Mrs. Godfrey, La Africana and Pink Star.

In the Victoria greenhouse these varities were infested: Smith's Advance, Halliday, Ivory, Polepheum, Chrysolora, Bonnaffon, Wm. Turner, Western King, Mrs. Thompson, Engluehard, various Pompons. Of these varieties Smith's Advance, Ivory, Bonnaffon, Wm. Turner, Western King, and Engluehard were practically ruined.

Felt states that the insect has been recorded from central and southern Europe as infesting *Chrysanthemum leucanthemum*, *C. corymbosum*, *C. atratum*, *C. japonicum* and *C. myconis*. In America the pest was first noticed on the variety known as Mistletoe.

CONTROL

The Chrysanthemum Midge has been not only controlled but wholly eradicated in certain greenhouses in Ontario and also in the United States by thoroughly spraying infested plants with the following mixture:—

Nicotine sulphate	1¼ teaspoonfuls
Soap	1 ounce
Water	1 gallon

The spraying should be done every second day for a period of about six weeks, or in other words as long as any lving insects remain in the galls. The mixture destroys the eggs, but it is applied primarily to kill the emerging adults. For this reason, and in view of the fact that the adults emerge during the night, it is advisable to do the spraying as late in the afternoon as possible.

In a badly infested greenhouse in south-western Ontario, the chrysanthemums were sprayed as outlined above, commencing about the middle of January, and the midge was wholly eradicated. On some varieties the consistent spraying caused a yellowish discoloration of the leaves; the plants, however, soon outgrew this injury and became healthy and vigorous.

PREVENTION

As the midge can apparently only be introduced on new stock, it should be possible to keep it out of greenhouses by taking the following precautions:

Carefully examine all new stock and, if any infested or questionable cuttings are found, burn them, and, as a further precautionary measure, dip all the others in the nicotine sulphate-soap solution recommended for spraying.

The Black Vine Weevil, *Otiorhynchus sulcatus* Fab.

This insect to which the name "Black Vine Weevil" has been given, is better known among florists as the Cyclamen Grub. Injuries in greenhouses have been reported from the provinces of British Columbia, Ontario, Quebec, and Nova Scotia. In the Montreal district it has been particularly destructive of late years and has caused important losses especially to cyclamens.

Fig. 19—Cyclamen plant showing injury to corm by the grubs of the Black Vine Weevil. Note stunted appearance of plant owing to roots having been eaten. (Original).

DESCRIPTION AND HABITS

The Egg.—The eggs of this weevil have not been found during any visits we have made to infested greenhouses. In general the egg is doubtless similar to that of the closely related Strawberry Root Weevil, which is small, spherical in shape and white in colour at first changing later to brown. This latter species lays eggs in the soil or on the crown of the plant.

The Larva or Grub.—The larva is legless, of a yellowish-white colour with a pale brownish head, and when mature is about three-eighths of an inch long. The upper surface of the body is covered with short reddish hairs. It lives entirely in the soil and in the case of cyclamen plants to which the chief injury in Canada has been caused, the accompanying illustration shows the damage it may do.

In serious infestations the roots are entirely eaten and in addition large cavities are eaten out of the corm. Under such conditions the growth of the plant is arrested, it becomes stunted and eventually dies.

The larvæ have been found in greenhouses throughout the late fall, winter and early spring months. When the grub is fully fed it makes an earthen cell within which it changes to the pupal state. These cells are about five-eighths of an inch long by about three-eighths of an inch wide. One larva, however, kept under observation pupated on the surface of the soil just below some dead leaves from the infested cyclamen plant without making an earthen cell. Others pupated normally in the soil at depths varying from one-half inch to one and one-half inches.

Fig. 20—Black Vine Weevil; grub at left; adult beetle in centre; pupa at right. Hair lines indicate natural size. (Original).

The Pupa.—The pupa is white, smooth, and in length about three-eighths of an inch.

The Beetle.—The adult insect, one of the snout beetles, is black in colour, with patches of yellow hairs on the wing covers which show up as spots. In length it is about three-eighths of an inch. The wing-covers are united and for this reason the beetle cannot fly and can only gain access to plants by walking.

Food Plants.—In Canada the insect has been found attacking the following plants in greenhouses: cyclamen, gloxinia, adiantum and several varieties of primula. In addition, in the United States, injury has been effected to palms, geraniums, etc. Out-of-doors, the insect in some sections of Nova Scotia and British Columbia is a rather important pest of strawberries and other plants.

CONTROL

Injecting Carbon Bisulphide into the Soil.—The introduction of carbon bisulphide into the soil to destroy the grubs has been suggested by some writers. Such experiments as we have been able to conduct with this chemical have not been successful.

Protection of Plants from Beetles.—Owing to the fact that the beetles cannot fly, it would seem that protection from the egg-laying females could be had to an important extent by using barriers of tanglefoot. Boards of one inch thickness, and six inches high, in length and width to fit the benches or beds, could be fastened together at the ends, the framework placed an inch or so in the soil and the upper outside edge covered with tanglefoot to prevent the beetles from gaining access to the enclosure containing the plants. To protect clothing a strip of thin wood two inches wide could be nailed to the top of the framework.

Crude Naphthaline.—As mentioned below, this material has been used experimentally with rather promising results at our entomological laboratory at Agassiz, B.C., for the destruction of weevil grubs. We have not, as yet, had an opportunity of testing its value for the Black Vine Weevil.

Fungus Gnat Maggots

Certain of the fungus gnat maggots of the family Mycetophilidæ are known to feed upon the tender roots of potted plants. We have received many complaints from various parts of Canada of the maggots being present in conspicuous numbers in the earth in which plants had been growing. A few of the species have been reared to the adult flies.

Neosciara coprohila Lint.—This species[1] has been reared by us from larvæ received from Winnipeg, Man., where in December, 1920, it was found in large numbers in mushroom beds. We have also received the species from greenhouses in Sudbury, Ont., (March, 1917), where the larvæ were abundant in the soil among the roots of ferns, begonia, erica and anemone. Hungerford[2] records undoubted injury by the larvæ—to geranium, begonia, fern, colias, etc. He states that the female flies lay from about seventy-five to one hundred and seventy-two eggs, these being placed in crevices in the soil; they hatch in six days. The maggots are whitish in colour and when full grown are about 7 mm. in length. The pupal stage lasts from five to six days. The adult fly is two-winged, the body being dark brown or blackish in colour; in length it is 2·5 mm.

Neosciara munda Jhn.—Female adults of apparently this species were present in large numbers in March, 1918, in important violet greenhouses at Brampton, Ont. No evidence was received indicating damage by the maggots to the root system. It is a larger species than the foregoing, measuring 3 mm. in length.

Neosciara prolifica Felt.—In 1899, the senior author found the adults of this species in violet houses in Toronto, Ont. No injury was noticed to the plants, nor did the grower have any evidence of damage. This fly is a conspicuous species, about the same size as *N. munda.*

CONTROL

Soap Suds.—We have on occasions recommended treating soil infested with these maggots, with strong soap suds. Some of our correspondents have reported favourably on this method of control. In the winter of 1918, one correspondent reported that an infested pot was placed "in a large pail containing strong soap suds, so that the water just reached the top of the soil; it was left there for a few hours, drained well afterwards, and since, no more worms have been seen".

Crude Naphthaline.—Certain florists in British Columbia use crude napthaline for soil-infesting insects. Soil for greenhouse purposes is impregnated with naphthaline in the proportion of two ounces to the cubic yard of soil. Further, crude naphthaline, is mixed with furnace ash and broadcasted over the benches on which potted plants are standing. At our Agassiz, B.C., laboratory, Mr. R. Glendenning has recently conducted limited tests, in confined quarters, with

[1]Determined by Dr. O. A. Johannsen
[2]Jour. Econ. Ent. IX, 538

this crude naphthaline, for the destruction of soil-infesting larvæ (*Epochra canadensis* and *Otiorhynchus ovatus*) and reports that rather promising control results were secured.

The Narcissus Bulb Fly, *Merodon equestris* F.

In eastern Canada, the damage caused by the maggot of this fly is apparently limited to the loss of imported narcissus bulbs in which the larvæ are present, but in British Columbia where the fly has become established and breeds in the open, damage may result from transferring bulbs from the garden to the greenhouse. The loss here also, is due only to the destruction of infested bulbs, as so far as we know, the flies do not breed under glass. Under field conditions in British Columbia, one florist lost 50,000 narcissus and daffodil bulbs in one year. The insect is of European origin, having been described from Italy. It is also known to occur in England, Holland and other European countries.

DESCRIPTION AND HABITS

The adult fly is almost one half an inch long and resembles a small "bumble bee" in appearance and actions. The egg is very small, oval in shape and white in colour. The larva or maggot is whitish or yellowish in colour and when full grown is from one-half to three-quarters of an inch in length. The larva pupates in the bulb or in the soil nearby.

Fig. 21—Narcissus bulbs infested with larvæ of Narcissus Bulb Fly. Bulb at left opened to show larva and its work. (Original).

The eggs are recorded as being laid at or near the base of the leaves of narcissi or on the necks of the bulbs when these are exposed. The young larvæ bore into the bulb and feed upon the tissues, which they rasp or tear apart by means of strong, hooked mouth-parts. The bulbs usually become soft and, in cases of imported bulbs at least, frequently rot. In the greenhouse the adult flies appear in January, but may occur during December and possibly February.

Food Plants.—"The bulbs attacked include the narcissus, hyacinth, tulip, amaryllis, habranthus, vallota, galtonia, scylla and leucojum. As regards narcissus it has been considered by a leading grower and authority on *Merodon* that the hard bulbs of the *N. maximanus* and *N. spurius* type are least attacked, while the most susceptible are the *N. poeticus* and *N. Leedsi* varieties, and, further, that varieties with coloured cups are more susceptible than those without".[1]

[1]Leaflet No. 286, Board of Agriculture and Fisheries (London, England).

CONTROL

The only control measure which we can suggest is the destruction before planting of all bulbs which are not absolutely firm, and all plants which die.

Under field conditions, in Europe, the annual lifting of the bulbs to destroy those containing the larvæ has been practised with success. The infested bulb is easily separated from the sound bulb.

The Small Narcissus Bulb Fly, *Eumerus strigatus* Fln.

This European insect was first found in Canada in 1904[1]; in fact this year is evidently the first record of the finding of the species in America. In Canada, the insect has been found in greenhouses in the larval and adult stages in the provinces of Quebec and British Columbia. Outside, the species has also been taken in the provinces of Ontario and Manitoba. In addition to the above popular name, it has also been called the Bulb Moon-fly, and the Lunate Onion Fly.

DESCRIPTION AND HABITS

The Larva or Maggot.—The larva has been described by MacDougall[2] as "half an inch and over when full grown. It is grayish-yellow in colour and has a distinctly wrinkled appearance. The mouth parts are brown and the respiratory processes at the front end are brownish-red. The rounded hind end is brown at the tip and has a projection on each side with a process which ends in the breathing pores between the projections."

Theobald[3] has found as many as seventeen larvæ in one bulb and states that "there is no doubt that these small narcissus and other bulb flies are the cause of much loss, but are not, it seems, so widely spread as *Merodon;* still the number one finds in samples of bulbs purchased shows that it has to be dealt with just as much as the larger maggot".

In October, 1910, the late Dr. C. Gordon Hewitt found the larvæ abundant in a greenhouse in Victoria, B.C. The owner of the greenhouse in the same year reared the adults from narcissus bulbs, the dates of emergence being April 7 to 9.

"In an advanced stage of the attack, the interior of the bulb is entirely destroyed and is full of a semi-liquid decaying mass. The attack seems to begin at the neck, and in mild cases, the larvæ are found in the neck or under the scales at one side. The presence of many larvæ and the complete decay produced distinguishes the damage done by *Eumerus* from that done by *Merodon*"[4].

The Adult.—The fly is much smaller than the Narcissus Bulb Fly, being about one-quarter of an inch in length. It is blackish-green in colour with white marks on the sides.

Food Plants.—This insect has been recorded as a pest of onions, shallot, roots of iris and bulbs of narcissus, hyacinth and amaryllis.

CONTROL

The remedy suggested above for the Narcissus Bulb Fly may be adopted in the case of the Small Narcissus Bulb Fly.

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[1]Canadian Entomologist, XLIX, 190
[2]Journal of the Board of Agriculture (London, Eng.), 1913.
[3]Report on Economic Zoology for year ending Sept. 30, 1911.
[4]Leaflet No. 286, Board of Agriculture and Fisheries (London, England).

The Cattleya Fly, *Isosoma orchidearum* Westw.

Reports of injury in Canada by this insect have been comparatively few, and such records as we have refer to infestations found in the province of Ontario. The insect is also known as the Orchid Isosoma.

DESCRIPTION AND HABITS

The adult insect is a small four-winged fly, less than one-eighth of an inch in length, with a black body. Regarding the oviposition habits of the female Davis[1] states that "the egg is placed in the centre of the small flower-bulb near the base, and the small larva hatching later, feeds on the tissues and burrows out a small cavity in the centre, the embryo flower-bud within being thus destroyed. Although the female usually inserts several eggs in a bulb, each one is deposited singly. The small, individual cavities, as they are enlarged by the larvæ, merge into a single larger burrow. When full grown the larva changes into a whitish pupa and later to the adult insect, which in due time escapes from the bulb. The infested bulbs, of course, fail to produce flowers.

Food Plants.—Orchids of the genus *Cattleya* are attacked.

CONTROL

Nicotine Fumigation.—In houses where this insect is found, control may be obtained by fumigating once a week with any of the well known-nicotine extracts sold by seedsmen. This fumigation which is intended to destroy the adult flies, should not be carried on when any of the orchids are in flower, owing to the fact that the strength of fumigation necessary to kill the flies, will undoubtedly injure the flowers.

ANIMAL PESTS OTHER THAN INSECTS

The Common Spider Mite, *Tetranychus telarius* Linn.

The well known spider mite, better known by the name Red Spider, is a common greenhouse pest. This mite occurs abundantly on a great variety of plants and specially develops under warm, dry conditions.

DESCRIPTION AND HABITS

The Egg.—This is very small, pale in colour at first and round or spherical in shape. The female mite deposits her eggs chiefly on the undersides of the leaves. A single female is known to have deposited as many as ninety-four eggs. As they develop they change colour, becoming reddish in shade. The eggs hatch in from five to seven days.

Immature and Adult Mite.—The young mite is of a pale pinkish colour with six legs. After the first moult, however, it has the normal number of legs, namely, eight. In the later stages the mite, is in general, similar in appearance. The adult mite is very variable in colour. Ewing[2] in his important contribution on this insect says:—

"Six colours can be easily recognized in our common spider mite, viz., green, yellow, orange, carmine, black and brown. Of these six colours, each of the first three may be generally distributed over the whole body, so that the entire individual looks either green or yellow or orange".

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[1]27th Rep. State Ent. Illinois, 1912.
[2]Bull. No. 121, Oregon Agric. Exp. Sta.

The mites feed chiefly on the undersides of the leaves, where they insert their piercing needle-like structures into the tissues and withdraw the liquid contents of the leaf cells. After an attack the leaves lose their colour, assuming a whitish or bleached appearance; when the infestation is severe all the leaves

Fig. 22—Foliage of sweet pea injured by Common Spider Mite. Adult of Spider Mite below, much enlarged. (Original).

may eventually shrivel and die. In the adult state particularly, the mite spins considerable silk. If the underside of an infested leaf is examined it will be seen to be covered by many strands of fine silk which have been spun in all directions by the mites. Recently (November, 1921) we examined a serious infestation in a large greenhouse in eastern Ontario, where the mites had developed to a remarkable extent and had spun large quantities of silk over the entire heads of magnificent single-stemmed chrysanthemums.

As mentioned above, the mite develops rapidly in warm dry situations, frequently so in houses where flowering plants are being forced and under conditions where care must be exercised in watering.

Food Plants.—The mite is found on a large number of plants grown indoors. Carnation, chrysanthemum, violet, rose, fuschia, geranium and other plants are frequently injured.

CONTROL

Sulphur-soap mixture—

Flowers of sulphur	1 ounce
Laundry soap	2 ounces
Water	1 gallon

Dissolve the soap in the water, then add the sulphur and spray the mixture in such a way as to reach the undersides of the leaves where the mites are feeding. A short angle nozzle will be found of value in forcing the spray well up among the foliage. Several sprayings a week or so apart may be necessary.

Water alone.—It has been the general experience of florists that forcible and frequent spraying with water alone will do much to hold this pest under control.

Destruction of Infested Plants.—Badly infested plants should be destroyed as soon as they are noticed. This is best done by burning.

The Flat Mite, *Tenuipalpus lineola* Can. and Fanz.*

Recently (April, 1922) another species of mite was found in an Ontario greenhouse feeding on *Acuba japonica*, and causing injury similar to that of the Common Spider Mite. The term Flat Mite, is suggested as an appropriate common name for this species.

DESCRIPTION AND HABITS

The mite is dark reddish in colour, pear-shaped, and is barely visible to the naked eye (.26 mm x .16 mm). Its characteristic flatness and the fact that it does not spin silk over the attacked leaf, readily separate the species from the Common Spider Mite.

The red, sub-cylindrical eggs are laid in small clusters on the leaf.

Food Plants.—In the United States the Flat Mite occurs on citrus trees and on certain greenhouse plants.

CONTROL

The remedial measures recommended for the Common Spider Mite would no doubt prove equally effective in controlling the Flat Mite.

Fig. 23—Sow Bugs feeding on manure. (Original.)

Sow Bugs

Sow bugs or wood lice so-called, are not insects but true crustaceans. They are often very destructive in greenhouses, being commonly found along the edges of beds, under decaying boards, etc.

*Determined by H. E. Ewing.

DESCRIPTION AND HABITS

These creatures when full grown are about half an inch in length, dark gray in colour and of an oval, flattened shape. They prefer dark situations where decay is taking place. They feed chiefly during the night.

Food Plants.—We have records of their having attacked the roots of orchids and ferns, of checking the growth of carnations and sweet peas, of injuring begonia and coleus cuttings, and of destroying the seedlings of asparagus, primula, petunia, lobelia, solanum and other plants.

CONTROL

Preventive Measures.—In combating these pests, it is important to deprive them as much as possible of hiding places. Discarded flats, old boxes, hay and other debris which harbour wood lice should not be permitted to accumulate beneath benches or around the house. All such refuse should be burned.

Another preventive measure of value is the coating of benches with a tar composition. The tar preserves the wood and thus robs the sow bugs of a favorite refuge—damp rotten wood—and while fresh it acts as a repellant.

Hot Water.—Many sow bugs may be killed by pouring hot water into the cracks and crevices in wooden partitions and benches, by applying it along the edges of greenhouse beds where large numbers of the creatures lie concealed, and by flushing cleared benches and the ground beneath them with it. This method of control can be used to greatest advantage in establishments where the water system can be temporarily connected with a boiler or where the steam or hot water pipes can be tapped.

Trapping.—Systematic trapping by means of inverted flower pots containing damp hay will very materially reduce the pests. The traps should be examined in the morning and the sow bugs destroyed.

Poisoning.—Various poisoned baits are of value in controlling sow bugs. The two following have been tested by commercial growers and have been found to be effective:

(1) Paris green.....1 part by weight.
Icing sugar.....10 parts by weight.

(2) Paris green.....1 part by weight.
Icing sugar.....2 parts by weight.
Rye flour.....2 parts by weight.

The bait should be scattered along the concrete or wooden sides of the beds and as soon as it becomes encrusted, a fresh supply of the mixture should be used.

Fig. 24—Slug, enlarged. (Original).

Slugs

Several kinds of slugs are found in greenhouses and not infrequently important damage is effected to various kinds of plants. These creatures, which of course, are not insects, but true molluscs are often referred to by growers as snails.

DESCRIPTION AND HABITS

Slugs are slimy, soft-bodied creatures, usually of a dark grayish colour and in length varying from one-half to three or four inches The larger ones which

have undoubtedly been introduced on nursery stock from Europe are darker in colour and are marked with stripes They are nocturnal in habit, hiding during the day beneath clods of earth, etc. They feed freely on the foliage of plants and where they have been working a slimy trail is left which, when dry, is shiny and easily noticed.

Food Plants.—As mentioned above, various kinds of plants are attacked; chrysanthemums, marigold, snapdragon, etc. During December, 1921, serious injury was effected to cineraria, coleus and geranium plants in a large greenhouse in Montreal,

CONTROL

Hand Picking.—If the plants are examined at night, the slugs may be seen feeding and numbers removed from the plants by hand.

Traps.—Shingles placed throughout infested beds will attract the slugs, forming as they do suitable hiding places. If they are turned over in the morning, the slugs present may be easily destroyed by scraping them off and crushing them with the foot.

Lime Applications.—As they come out to feed in the evening an excellent remedy is to broadcast lightly over the soil before nightfall, freshly slaked lime. This adheres to their bodies and soon kills them. Two or three applications on consecutive evenings are advisable.

Millipedes

Several species of millipedes or "thousand legged worms" creatures related to insects have, quite commonly, been found in numbers in greenhouses in Canada. Although millipedes are known to injure seedlings and to attack the roots of plants, it is well known that their natural food is decaying vegetable matter. It is their presence that is chiefly objectionable to growers. In this regard an interesting infestation of the Greenhouse or Hothouse Millipede, *Oxidus gracilis* (C. L. Kock), recently occurred in a greenhouse in western Ontario. The worms were present in large numbers, but the owner of the house did not find that they injured any plants,

Fig. 25—A common millipede. (Original).

DESCRIPTION AND HABITS

Millipedes, in general, may be described as rather slender, worm-like, cylindrical creatures, with a hard surface. The life-history of these creatures is by no means well known. In the case of the Greenhouse Millipede it is known that the females deposit whitish eggs in masses in the soil. A single female may lay as many as 300 eggs, which hatch in about three weeks. The young millepedes are, in general appearance, except in size, similar to the adults.

CONTROL

Dry Surface Applications.—Dressings of lime, and lime soot, or tobacco dust have been recommended. A mulch of tobacco dust about one-half inch to one inch deep worked into the soil has proved of special value.

Wet Applications.—In Ontario, control has been secured by spraying seedling flats at night with a 40 per cent nicotine extract (1-400) after which the flats were covered with glass. In other experiments it has been found that drenching the beds with a similar mixture in the strength of one part to 700 of water has been of value.

Traps.—Some writers recommend the placing of pieces of potato dipped in a Paris green solution among the plants, others the use of lumps of dough sweetened with molasses. These latter should be collected and the millipedes attracted thereto destroyed.

The Root-knot Nematode, *Heterodera radicicola* Mull.

Greenhouse plants, particularly tomatoes and cucumbers, are frequently injured by a microscopic worm known as the Root-knot Nematode or eelworm. The worm enters the roots from the soil and feeds upon the sap.

Fig. 26—Healthy cyclamen plant in pot at left; plant at right destroyed by nematodes. (Original).

DESCRIPTION AND HABITS

Nematodes are not insects but belong to a group of animals designated as "round worms". They occur in the soil as immature, thread like worms, and, as previously stated, bore their way into the roots of plants. Within the root tissues they develop into males (minute elongate worms) and females, (small pear-shaped bodies half the size of the head of a pin). The eggs are laid inside the galls and the larvæ, which hatch from them, work their way out to the soil and attack other plants. The irritation of the tissues, caused by their feeding activities, results in the production on the roots of abnormal swellings or galls which vary greatly in size and shape (fig. 26). The injury to the roots naturally robs the plants of vigour; checks the growth; materially reduces the set of fruit, in the case of tomatoes; and, if severe, causes premature death.

Food Plants.—The Root-knot Nematode has almost a world-wide distribution and it is known to have over 500 host plants. In southern United States, it is a serious pest of truck and garden crops, but fortunately in Canada, although it is said to have been occasionally found out-of-doors in southern Ontario, it is only of importance as a greenhouse pest. It infests lettuce, cyclamen, violets, etc., but, under our conditions, it is primarily a pest of tomatoes and cucumbers.

CONTROL

In view of the fact that the nematodes occur in the soil and survive over a considerable period, there are only two possible ways of getting rid of them: (1) by changing the soil, or (2) by sterilizing the soil with steam or with some chemical as described herewith.

Fig. 27—Tomato roots showing swellings, or galls, resulting from nematode infestation. (Original).

SOIL STERILIZATION

It is generally conceded that where live steam and other necessary facilities are available, the use of steam is the most satisfactory method of disinfecting the soil. Two methods of steam sterilization are generally used: one called the "inverted pan method," and the other "the pipe method".

The Inverted Pan Method—The apparatus used in connection with this system of soil disinfection consists of a galvanized iron pan, about 6 feet by 10 feet by 6 inches,[1] with sharp edges, with steam hose connections and with handles. In using it the sharp edges of the inverted pan are forced well into the soil and steam is then admitted. The steam should be maintained at as high a pressure as possible, 80 to 100 pounds, and the treatment should be continued for one or two hours depending on the pressure. The most convenient method of

[1]The exact size of the pan should be determined by the dimensions of the beds.

determining when the process of sterilization has gone far enough, is to bury potatoes in the soil at a depth of about one foot, and when they are thoroughly cooked, the steam may be turned off.

The Pipe Method.—In this method the steam is applied by means of a set of one and a quarter inch or one and a half inch pipes, perforated with holes one-eighth to one-quarter inch in diameter and about one foot apart. The number and length of the pipes should conform to the boiler capacity and length of beds. According to Selby and Humbert[1], the perforated pipes should not be more than 40 feet in length, nor exceed seven or eight in number. With medium boiler capacity, say 50 to 60 horse-power, pipes 30 feet in length are most serviceable. The pipes should be about 16 inches apart and should be connected with a 2-inch crosshead by means of T connections.

In using this system, the pipes are buried at a depth of about 6 inches, care being taken to see that they lie level. The soil is then levelled and covered with canvas or sacking to check the escape of steam. Here again potatoes may be used to determine the duration of the treatment, but in this case the potatoes should be placed near the surface.

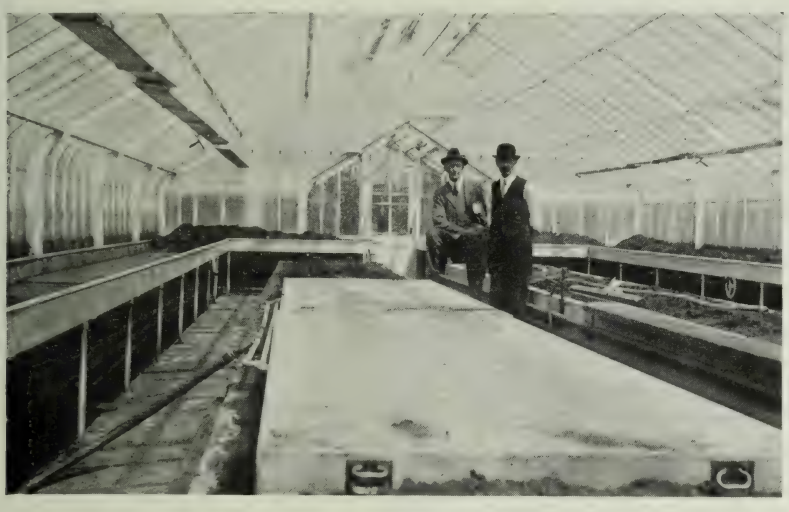

Fig. 28—Showing inverted pan method of sterilizing soil. (Original).

Steam sterilization not only eradicates nematodes, but it also rids the soil of all insect life; of pests such as sow bugs; of injurious fungi such as those which cause damping-off, lettuce drop and *Rhizoctonia*, and of weed seeds. It also has the advantage of improving the soil conditions and, for this reason, it is said that sterilized soil requires less fertilizer than untreated soil.

CHEMICAL TREATMENT

Where live steam is not available or where for other reasons the use of steam is impracticable, chemical treatment must be resorted to. Chemicals such as carbon-bisulphide, formalin and calcium cyanamide are sometimes used for this purpose, but apparently the most satisfactory soil fumigant for the control of nematodes is sodium cyanide used in combination with ammonium sulphate.[2] A dosage of three ounces of sodium cyanide and four and one-half ounces of ammonium sulphate to the square yard should be used.

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[1]Circular No. 151, Ohio Agr. Exp. Sta., 1915.
[2]Bull. 159, Agr. Exp. Sta., Florida, 1921.

The bed should first of all be dug over and then cyanide, dissolved in water, should be poured, by means of a sprinkling can, evenly over the soil and washed in so that the soil will be soaked to a depth of 18 inches or so. The ammonium sulphate, dissolved in water, should then be sprinkled over the soil and likewise washed in. It is important that the ammonium sulphate should be applied as soon after the cyanide as possible, in order to accelerate the decomposition of the latter and the consequent liberation of the hydrocyanic acid fumes, which kill the nematodes.

Experience has shown that, if the ventilators are open while the beds are being treated, the fumes will not inconvenience the operator to any extent worth mentioning. Experience has also shown, that soil sterilized by this method should not be used for planting until two weeks after treatment.

Fig. 29—Foliar nematode, *Aphelenchus ormerodes;* separate drawings showing details of anatomy. All much enlarged. (Original).

Foliar Nematodes

We have occasionally found nematode or eelworm attack upon the leaves of greenhouse plants, particularly ferns (*Pteris* spp.). On such plants, large brownish coloured areas were present on the fronds of young plants, due to the presence of eelworms.

Fig. 30—Fern leaves injured by foliar nematode (*Aphelenchus ormerodes*). (Redrawn after Marcinowski).

In 1915, an eelworm (*Aphelenchus ormerodes*) infested fern from Hamilton was received. This was placed in a greenhouse and with ordinary attention it was noted that it outgrew the injury. This fern at present is in excellent condition.

The remedial measure which is frequently recommended of dipping the affected leaves in water at 50 degrees C. for two to five minutes is considered impracticable by florists. Soil sterilization is apparently the only effective method of controlling this and other species of eelworms. As infection is spread by contact, healthy plants should not be allowed to come into contact with infested ones.

The Cyclamen Mite, *Tarsonemus pallidus* Banks

During recent years great difficulty has been experienced in growing cyclamens successfully, owing to the depredations of the Cyclamen Mite. Mite injury was noticed in Ontario as early as 1908, but apparently there was no serious outbreak of the pest until 1916, at which time our attention was first directed to it. That year it caused severe injury to cyclamens in several Ontario greenhouses, and since then it has been decidedly troublesome, not only in the province of Ontario, but also in the province of Quebec, so much so as to discourage the growing of cyclamens.

In the United States, the mite was first noticed in New York state in 1898, at which time it was named and described. Since then it has been recorded from many states and no doubt occurs wherever cyclamen stock is grown.

Fig. 31—Cyclamen bloom destroyed by the Cyclamen Mite; healthy bloom at right. (Original).

DESCRIPTION AND HABITS

The adult mites are pale, shiny-brown, ovate creatures with four pairs of legs. They are about .2 mm. or 1/125 inch in length. The immature forms are translucent and have only three pairs of legs. The eggs are oval, hyaline bodies about 12 mm. x .06 mm. All stages are barely visible to the naked eye.

The mites, in all stages, occur on the tender foliage, on the buds, and on the bloom. They will attack almost any part of the flower—the petals, stamens and ovary, but as a rule, most of them are found between the calyx and corolla.

Food Plants and Injury.—In the United States the mite has been recorded as a pest of chrysanthemums, snapdragons, fuchsias and geraniums as well as cyclamens, but in this country it has been observed so far only on cyclamen.

On cyclamens the mite produces what florists usually term the "cyclamen disease." Attacked flowers become distorted, blotched, streaked and flaccid in appearance and die prematurely. In many cases, the flower buds do not open but gradually wilt and die. Infested foliage becomes curled, and at the point of attack little depressions or pockets may be found, and the leaf epidermis may assume a dark, purplish and cracked appearance Badly injured cyclamens are absolutely worthless.

CONTROL

Systematic spraying with a nicotine soap solution is, at the present time, the only promising remedial measure which can be recommended. From the time the plants are one inch to one and a half inches high until the flower buds are beginning to show some colour, the plants should be thoroughly sprayed every week with the following mixture:—

Nicotine sulphate	$1\frac{1}{2}$ teaspoonfuls
Soap	$\frac{3}{4}$ ounce.
Water	1 gallon.

Unfortunately we have no very definite data as to the value of this treatment. Some growers claim that it is very effective, and others maintain that it is unsatisfactory. To the writers, it appears highly probable that failure to control the mite is due, in many cases, to leaving out the soap, and in others to a lack of thoroughness. It is possible, as one florist suggests, that dipping would prove more satisfactory than spraying, as this would insure covering all parts of the plant with the mixture.

The Bulb Mite, *Rhizoglyphus hyacinthi* Banks

Shipments of bulbs arriving in Canada from Europe have, during recent years, been noticeably infested by the Bulb Mite. This mite is abundant in several European countries and has also been found in the United States on bulbs imported from Japan and the Bermuda Islands.

DESCRIPTION AND HABITS

The mite is very small and can hardly be seen without the aid of a good lens. It is whitish in colour, frequently with a pinkish tinge. The mite may be present on the bulb in all stages—egg, larva, nymph, etc. On hatching from the egg, the larva bears six legs. After feeding for a short time, this six-legged larva becomes inert and moults. The new form has eight legs and is known as a nymph, and it is during this stage that the greatest growth takes place. Larva, nymph, and adult do not greatly differ from one another in external appearance[1]. Important signs of infestation are: the checking of the growth of the plants, the leaves turning yellowish; failure of the plants to produce flowers; and the presence of reddish brown spots on the scales of the bulb indicating the feeding places of the mites. Recently we have had an opportunity of discussing the Bulb Mite with expert bulb growers from Holland. There is still doubt as to the primary cause of the injury; the Holland growers are apparently convinced that this is not caused by the mite.

Food Plants.—The Bulb Mite has been found in Canada commonly on imported narcissi, hyacinth and tulip bulbs and in the greenhouse on easter lily bulbs.

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[1]Leaflet 136, Board of Agriculture and Fisheries, (London, England).

CONTROL

German[1] states that "one of the most satisfactory means of killing the mites was found to be that of dipping the bulbs in nicotine sulphate 1-400, or nicotine oleate, heated to 50° C. Hot water (50°C.) also kills a good percentage."

Fig. 32—Tulip bulb infested with the Bulb Mite; outside layer of bulb turned back to show feeding places of mite. (Original).

Healthy bulbs only should be planted. All soft or partly rotten ones should be destroyed by burning. Soil in which infested bulbs have been present should not be used for healthy bulbs.

Earthworms

Generally speaking, earthworms are beneficial. By burrowing here and there and by feeding on the soil they have the effect of breaking up the soil and of making it more accessible to air, moisture, bacteria and the roots of plants. Occasionally, however, in heavily manured greenhouse beds they become so numerous that they are a decided nuisance. For example, in 1920, there was a veritable plague of earthworms in the rose beds of a large Ontario greenhouse. The earth was literally alive with these worms; the manure disappeared rapidly; the soil lost its friability, and became lumpy, porous and somewhat "sticky"; and the worms apparently disturbed the roots of the roses.

[1]Bull. 225, Conn. Agric. Exp. Sta.

At the suggestion of the writers, the beds in this greenhouse were given a very light dressing of hydrated lime and the lime was then washed in. This treatment was successful—it destroyed most of the worms and at the same time caused no injury to the rose plants.

NATURAL CONTROL

Most insect pests are very prolific and, in the case of some species, their powers of multiplication are simply astounding. For example, it has been estimated that, if all the progeny of a single rose aphid were to survive, they would at the end of 300 days be equal in weight to the population of China sevenfold. Fortunately for us, Nature does not permit these great powers of multiplication to have full play, otherwise a single species might soon overrun the earth. Insects are preyed upon by other insects and by other animals, such as birds, toads, and frogs; they are attacked by fungous and bacterial diseases; and they are held in check by unfavourable weather conditions. In the field, garden, orchard and forest, these various factors, collectively termed Natural Control, are of vital importance in protecting our crops from the ravages of insects. Indeed, were it not for Natural Control, it would be impossible to grow many of our most important crops. In the greenhouse, because of the artificial conditions obtaining there, Natural Control does not play nearly as vital a part as it does out-of-doors; nevertheless, various natural enemies of insects are a great aid to the greenhouse grower in reducing the numbers of some injurious species. Among these natural enemies the following may be mentioned:

Predacious Enemies

Ladybird beetles, both in the larval and adult stages, feed voraciously on aphids and on other small insects. Experiments have shown that one beetle

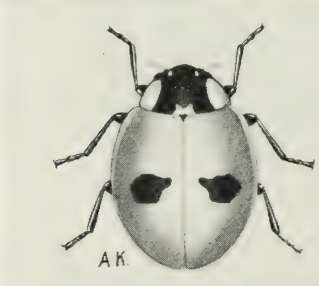

Fig. 33—Ladybird Beetle, *Adalia bipunctata*, enlarged about five times. (After Ross).

Fig. 34—Larva of Ladybird Beetle, enlarged about three times. (After Ross).

may devour about 100 aphids daily. The adult ladybird beetles (fig. 33) are easily recognized by their oval, hemispherical shape and their conspicuous colouring. Most of them are red or yellow with black markings or black with red markings. The larvæ are alligator-like grubs (fig. 34). Many of the syrphid larvæ (fig. 35) also feed upon aphids.

Predacious mites, small, oval-bodied, eight-legged creatures, are important in controlling the Common Spider Mite. Spiders by preying on injurious flies and other insects are of value. For example, one species, *Salticus senicus*,[1] has been observed attacking aphids, leaf-rollers, and other injurious insects.

[1]Bull. 157, Mass. Agr. Exp. Sta. Nov. 1914, p. 50.

Internal Parasites

Various species of four-winged flies, called parasitic hymenoptera, destroy caterpillars and other insects by living within them as internal parasites. Probably the most common four-winged parasites found in greenhouses are the minute flies (*Aphidius*) which destroy aphids. The female flies deposit their eggs singly in the aphids. The larvæ which hatch from the eggs undergo all their transformations within the aphids' bodies, (fig. 15, 2) and, in due course, emerge as adult flies. We have seen an outbreak of "green fly" on greenhouse radishes almost completely brought under control by these parasites.

Fig. 35—Syrphid larva feeding on aphids. (Original).

PUBLICATIONS ON INSECT PESTS

The following publications of the Department of Agriculture relating to Insects are available on application to the Publications Branch, Department of Agriculture, Ottawa:—

Root Maggots and Their Control.....C. P. L. No. 4
Aphids or Plant Lice.....C. P. L. No. 8
Pea Weevil, The.....C. P. L. No. 9
Lime, Arsenate of.....C. P. L. No. 10
Cutworms, Date to Reseed Fields Devastated by.....C. P. L. No. 11
Beet Webworm, The.....C. P. L. No. 12
Corn Borer, The Control of the European.....C. P. L. No. 16

Tent Caterpillars.....Cir. No. 1
Flea Beetles and Their Control.....Cir. No. 2
Chinch Bug in Ontario, The.....Cir. No. 3
Insects and Their Control, Common Garden.....Cir. No. 9
Tussock Moth, The Habits and Control of the White-marked.....Cir. No. 11
Directions for Collecting and Preserving Insects.....Cir. No. 12
Boring Caterpillars which are Liable to be Mistaken for the European Corn Borer...Cir. No. 14

Army-Worm, The.....Bull. No. 9
Pear Thrips, The.....Bull. No. 15
Apple Bud-Moths and Their Control in Nova Scotia, The.....Bull. No. 16
Fruit Worms of the Apple in Nova Scotia, The.....Bull. No. 17
Cleorini (Geometridae) Studies in North America.....Bull. No. 18